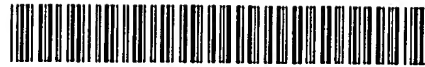


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(54) **EXHAUST GAS CLEANING APPARATUS FOR INTERNAL COMBUSTION ENGINES**

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EPURATEUR DE GAZ D'ECHAPPEMENT POUR MOTEURS A COMBUSTION INTERNE

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(56) References cited:  
**JP-A- 1 030 643** **JP-A- 2 149 714**  
**JP-A- 2 149 715** **JP-A- 3 124 909**  
**JP-A- 4 171 215** **JP-A- 5 076 771**  
**JP-A- 53 115 687** **JP-A- 60 182 325**  
**JP-B- 1 056 816** **JP-U- 62 126 508**

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**EP 0 625 633 B1**

## Description

[0001] The present invention relates to a purification process for purifying exhaust gas of an internal combustion engine.

## BACKGROUND ART

[0002] The present applicant has already proposed an internal combustion engine in which a lean air-fuel mixture is burned, in which internal combustion engine an NO<sub>x</sub> absorbent which absorbs the NO<sub>x</sub> when the air-fuel ratio of an inflowing exhaust gas is lean and releases the absorbed NO<sub>x</sub> when the oxygen concentration in the inflowing exhaust gas is lowered is arranged in an engine exhaust passage; the NO<sub>x</sub> generated when the lean air-fuel mixture is burned is absorbed by the NO<sub>x</sub> absorbent before the NO<sub>x</sub> absorption capability of the NO<sub>x</sub> absorbent is saturated, the air-fuel ratio of the inflowing exhaust gas to the NO<sub>x</sub> absorbent is temporarily made rich so that the NO<sub>x</sub> absorbent is made to release the NO<sub>x</sub> and, at the same time, the released NO<sub>x</sub> is reduced EP-A-0.560.991 published 22.09.93.

[0003] However, the fuel and the lubrication oil of the engine contain sulfur, and therefore SO<sub>x</sub> is contained in the exhaust gas. Accordingly, in this internal combustion engine, this SO<sub>x</sub> is also absorbed into the NO<sub>x</sub> absorbent together with the NO<sub>x</sub>. However, this SO<sub>x</sub> is not released from the NO<sub>x</sub> absorbent even if the air-fuel ratio of the inflowing exhaust gas to the NO<sub>x</sub> absorbent is made rich, and accordingly the amount of SO<sub>x</sub> in the NO<sub>x</sub> absorbent is gradually increased. However, when the amount of SO<sub>x</sub> in the NO<sub>x</sub> absorbent is increased, the amount of the NO<sub>x</sub> that can be absorbed by the NO<sub>x</sub> absorbent is gradually lowered, and finally the NO<sub>x</sub> absorbent becomes no longer able to absorb almost any NO<sub>x</sub>. Therefore, the present applicant has already proposed an internal combustion engine in which a sulfur trap is provided in the engine exhaust passage at the upstream side of the NO<sub>x</sub> absorbent, and the SO<sub>x</sub> contained in the exhaust gas is caught by this sulfur trap EP-A-0.582.917, published 16.02.94. In this internal combustion engine, the SO<sub>x</sub> discharged from the engine is caught by the sulfur trap, and therefore only the NO<sub>x</sub> is absorbed into the NO<sub>x</sub> absorbent.

[0004] However, in this internal combustion engine, the SO<sub>x</sub> caught by the sulfur trap is continuously being caught in the sulfur trap without being released from the sulfur trap even if the air-fuel ratio of the exhaust gas flowing into the sulfur trap is made rich. Accordingly, the amount of the SO<sub>x</sub> caught by the sulfur trap is gradually increased. When the SO<sub>x</sub> catching capability of the sulfur trap is saturated, the SO<sub>x</sub> passes through the sulfur trap, and therefore there arises a problem in that the SO<sub>x</sub> is absorbed into the NO<sub>x</sub> absorbent and gradually accumulates in the NO<sub>x</sub> absorbent.

## DISCLOSURE OF THE INVENTION

[0005] The object underlying the invention is to provide a purification process for purifying exhaust gas of an internal combustion engine provided with an NO<sub>x</sub> adsorbent and an SO<sub>x</sub> adsorbent, both arranged in the exhaust passage of the internal combustion engine, wherein the SO<sub>x</sub> adsorbent is arranged upstream of the NO<sub>x</sub> adsorbent. Further, an exhaust purification device for conducting the process should be provided.

[0006] This object is solved by the features of claim 1. According to the invention, an air-fuel ratio control means usually maintains the air-fuel ratio of the exhaust gas flowing into said SO<sub>x</sub> adsorbent lean and makes the air-fuel ratio of the exhaust gas flowing into said SO<sub>x</sub> adsorbent rich, when the SO<sub>x</sub> should be released from the SO<sub>x</sub> adsorbent to ensure that the SO<sub>x</sub> adsorbent is capable of absorbing SO<sub>x</sub> during the usual operation conditions.

[0007] In the following description advantageous embodiments of the invention are described.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Figure 1 is an overall view of an internal combustion engine; Fig. 2 is a view showing a map of a basic fuel injection time; Fig. 3 is a view showing a change of a correction coefficient K; Fig. 4 is a graph schematically showing a concentration of unburnt HC and CO and oxygen in an exhaust gas discharged from the engine; Figs. 5A and 5B are views for explaining an NO<sub>x</sub> absorption and releasing function; Fig. 6 is a view showing a releasing timing of the NO<sub>x</sub> and SO<sub>x</sub>; Fig. 7 is a flow chart showing an interruption routine; Fig. 8 is a flow chart for calculating a fuel injection time TAU; Fig. 9 is an overall view showing another embodiment of the internal combustion engine; Fig. 10 is an overall view showing still another embodiment of the internal combustion engine; Fig. 11 is a flow chart for performing the NO<sub>x</sub> releasing processing; Fig. 12 is an overall view showing further another embodiment of the internal combustion engine; Fig. 13 is a view showing a releasing characteristic of the SO<sub>x</sub>; Fig. 14 is a view showing the SO<sub>x</sub> and NO<sub>x</sub> releasing timing; Fig. 15 is a view showing a rich control at the time of releasing of NO<sub>x</sub>; Figs. 16A to 16C are views showing a relationship between various types of parameters and an exhaust gas temperature; Fig. 17 is a view showing the rich control at the time of releasing of SO<sub>x</sub>; Figs. 18A to 18D are views showing a relationship between various types of parameters and the exhaust gas temperature; Fig. 19 is a view showing a map of the exhaust gas temperature; Fig. 20 and 21 are flow charts for calculating the correction coefficient KK; Fig. 22 is a flow chart for calculating the fuel injection time TAU; Fig. 23 is an overall view showing still another embodiment of the internal combustion engine; Fig. 24 is a view showing a map of the basic fuel injection time; Fig. 25 is a view showing the

correction coefficient K; Figs. 26A and 26B are graphs showing an NO<sub>x</sub> releasing rate and an SO<sub>x</sub> releasing rate; Figs. 27A and 27B are graphs showing a cumulative release of the NO<sub>x</sub> and SO<sub>x</sub>; Fig. 28 is a timing chart of an SO<sub>x</sub> releasing control; Fig. 29 is a timing chart of an SO<sub>x</sub> and NO<sub>x</sub> releasing control; Fig. 30 is a timing chart of the SO<sub>x</sub> and NO<sub>x</sub> releasing control; Fig. 31 is a timing chart showing the change of the air-fuel ratio of the NO<sub>x</sub> and SO<sub>x</sub> releasing control, etc.; Figs. 32A to 32D are flow charts of a flag switch valve control; Fig. 33 is a view showing the map of the exhaust gas temperature T; Fig. 34 is a flow chart for calculating the fuel injection time TAU; Figs. 35A to 35D are flow charts of the flag switch valve control; Fig. 36 is a flow chart for calculating the fuel injection time TAU; Figs. 37A to 37D are flow charts of the flag switch valve control; Fig. 38 is a flow chart for calculating the fuel injection time TAU; Figs. 39A to 39D are flow charts of the flag switch valve control; and Fig. 40 is a flow chart for calculating the fuel injection time TAU.

#### BEST MODE FOR WORKING THE INVENTION

[0009] Figure 1 shows a case where the present invention is applied to a gasoline engine.

[0010] Referring to Fig. 1, 1 denotes an engine body; 2, a piston; 3, a combustion chamber; 4, a spark plug; 5, an intake valve; 6, an intake port; 7, an exhaust valve; and 8, an exhaust port; respectively. The intake port 6 is connected via a corresponding branch pipe 9 to a surge tank 10, and fuel injectors 11 for injecting the fuel toward inside the intake port 6 are attached to the respective branch pipes 9, respectively. The surge tank 10 is connected via an intake duct 12 and an air flow meter 13 to an air cleaner 14, and a throttle valve 15 is arranged in the intake duct 12. On the other hand, the exhaust port 8 is connected via the exhaust manifold 16 and the exhaust pipe 17 to a casing 20 accommodating an SO<sub>x</sub> absorbent 18 and an NO<sub>x</sub> absorbent 19. The SO<sub>x</sub> absorbent 18 is arranged on the upstream side of the NO<sub>x</sub> absorbent 19. In the embodiment shown in Fig. 1, the SO<sub>x</sub> absorbent 18 and the NO<sub>x</sub> absorbent 19 are integrally formed using one monolithic carrier made of for example alumina.

[0011] An electronic control unit 30 comprises a digital computer and is provided with a ROM (read only memory) 32, a RAM (random access memory) 33, a CPU (microprocessor) 34, an input port 35, and an output port 36, which are mutually connected by a bidirectional bus 31. The air flow meter 13 generates an output voltage in proportion to the intake air amount, and this output voltage is input via an AD converter 37 to the input port 35. Also, a rotational speed sensor 21 generating an output pulse expressing the engine rotational speed is connected to the input port 35. On the other hand, the output port 36 is connected via a corresponding drive circuit 38 to the spark plug 4 and the fuel injector 11, respectively.

[0012] In the internal combustion engine shown in Fig. 1, the fuel injection time TAU is calculated based on for example the following equation:

$$TAU = TP \cdot K$$

[0013] Here, TP indicates the basic fuel injection time; and K indicates the correction coefficient. The basic fuel injection time indicates a fuel injection time necessary for making the air-fuel ratio of the air-fuel mixture fed into the engine cylinder the stoichiometric air-fuel ratio. This basic fuel injection time TP is found in advance by experiments and stored in advance in the ROM 32 in the form of a map as shown in Fig. 2 as a function of the engine load Q/N (intake air amount Q/engine rotational speed N) and the engine rotational speed N. The correction coefficient K is a coefficient for controlling the air-fuel ratio of the air-fuel mixture fed into the engine cylinder, and if K = 1.0, the air-fuel mixture fed into the engine cylinder becomes the stoichiometric air-fuel ratio. Contrary to this, when K becomes smaller than 1.0, the air-fuel ratio of the air-fuel mixture fed into the engine cylinder becomes larger than the stoichiometric air-fuel ratio, that is, becomes lean, while when K becomes larger than 1.0, the air-fuel ratio of the air-fuel mixture fed into the engine cylinder becomes smaller than the stoichiometric air-fuel ratio, that is, becomes rich.

[0014] This correction coefficient K is controlled in accordance with the operating state of the engine. Figure 3 shows one embodiment of control of the correction coefficient K. In the embodiment shown in Fig. 3, during a warm-up operation, the correction coefficient K is gradually lowered as the engine coolant temperature becomes higher. When the warm up is completed, the correction coefficient K is maintained at a constant value smaller than 1.0, that is, the air-fuel ratio of the air-fuel mixture fed into the engine cylinder is maintained lean. Subsequently, when an acceleration operation is carried out, the correction coefficient K is made for example 1.0, that is, the air-fuel ratio of the air-fuel mixture fed into the engine cylinder is made the stoichiometric air-fuel ratio. When a full load operation is carried out, the correction coefficient K is made larger than 1.0, that is, the air-fuel ratio of the air-fuel mixture fed into the engine cylinder is made rich. As seen from Fig. 3, in an embodiment shown in Fig. 3, the air-fuel ratio of the air-fuel mixture fed into the engine cylinder is maintained at the constant lean air-fuel ratio except at the time of a warm-up operation, the time of an acceleration operation, and at the time of a full load operation. Accordingly in most of the engine operating regions, a lean air-fuel mixture will be burned.

[0015] Figure 4 schematically shows the concentration of representative components in the exhaust gas discharged from the combustion chamber 3. As seen from Fig. 4, the concentration of the unburnt HC and CO in the exhaust gas discharged from the combustion

chamber 3 is increased as the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes richer, while the concentration of the oxygen  $O_2$  in the exhaust gas discharged from the combustion chamber 3 is increased as the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes leaner.

[0016] The  $NO_x$  absorbent 19 accommodated in the casing 20 uses for example alumina as the carrier. This carrier carries at least one substance selected from alkali metals such as potassium K, sodium Na, and cesium Cs, alkali earths such as barium Ba and calcium Ca, and rare earths such as lanthanum La and yttrium Y and a precious metal such as platinum Pt. Note that, desirably lithium Li is added to this  $NO_x$  absorbent 19. When calling the ratio between the air and fuel (hydrocarbons) fed into the engine intake passage and the exhaust passage on the upstream side of the  $NO_x$  absorbent 19 the air-fuel ratio of the inflowing exhaust gas to the  $NO_x$  absorbent 19, this  $NO_x$  absorbent 19 performs the function of  $NO_x$  absorption and releasing of absorbing the  $NO_x$  when the air-fuel ratio of the inflowing exhaust gas is lean, while releasing the absorbed  $NO_x$  when the oxygen concentration in the inflowing exhaust gas is lowered. Note that, where the fuel (hydrocarbons) or air is not fed into the exhaust passage on the upstream side of the  $NO_x$  absorbent 19, the air-fuel ratio of the inflowing exhaust gas coincides with the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3, and accordingly, in this case, the  $NO_x$  absorbent 19 will absorb the  $NO_x$  when the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is lean, while releases the absorbed  $NO_x$  when the oxygen concentration in the air-fuel mixture fed into the combustion chamber 3 is lowered.

[0017] When the above-mentioned  $NO_x$  absorbent 19 is arranged in the engine exhaust passage, this  $NO_x$  absorbent 19 actually performs the  $NO_x$  absorption and releasing action, but there are areas of uncertainty about the detailed mechanism of this absorption and releasing function. However, this absorption and releasing function is considered to be carried out by the mechanism as shown in Figs. 5A and 5B. Next, this mechanism will be explained taking as an example a case where platinum Pt and barium Ba are carried on the carrier, but the same mechanism is realized even if another precious metal, alkali metal, alkali earths, or rare earths is used.

[0018] Namely, when the inflowing exhaust gas becomes considerably lean, the oxygen concentration in the inflowing exhaust gas is greatly increased, and as shown in Fig. 5A, this oxygen  $O_2$  is deposited on the surface of the platinum Pt in the form of  $O_2^-$  or  $O^{2-}$ . On the other hand, the NO in the inflowing exhaust gas is reacted with  $O_2^-$  or  $O^{2-}$  on the surface of the platinum Pt and becomes  $NO_2$  ( $2NO + O_2 \rightarrow 2NO_2$ ). Subsequently, a part of the produced  $NO_2$  is oxidized on the platinum Pt, while absorbed into the absorbent, and bonded with the barium oxide BaO, while diffused in the form of the

nitric acid ion  $NO_3^-$  into the absorbent as shown in Fig. 5A. In this way, the  $NO_x$  is absorbed into the  $NO_x$  absorbent 19.

[0019] So far as the oxygen concentration in the inflowing exhaust gas is high, the  $NO_2$  is produced on the surface of the platinum Pt, and so far as the  $NO_x$  absorption capability of the absorbent is not saturated, the  $NO_2$  is absorbed into the absorbent and the nitric acid ion  $NO_3^-$  is produced. Contrary to this, when the oxygen concentration in the inflowing exhaust gas is lowered and the amount of production of  $NO_2$  is lowered, the reaction is advanced in a reverse direction ( $NO_3^- \rightarrow NO_2$ ), thus the nitric acid ion  $NO_3^-$  in the absorbent is released in the form of  $NO_2$  from the absorbent. Namely, this means that, when the oxygen concentration in the inflowing exhaust gas is lowered, the  $NO_x$  will be released from the  $NO_x$  absorbent 19. As shown in Fig. 4, when the degree of leanness of the inflowing exhaust gas becomes low, the oxygen concentration in the inflowing exhaust gas is lowered, and accordingly when the degree of leanness of the inflowing exhaust gas is lowered, even if the air-fuel ratio of the inflowing exhaust gas is lean, the  $NO_x$  will be released from the  $NO_x$  absorbent 19.

[0020] On the other hand, when the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich and the air-fuel ratio of the inflowing exhaust gas becomes rich, as shown in Fig. 4, a large amount of unburnt HC and CO are discharged from the engine, and these unburnt HC and CO are reacted with the oxygen  $O_2^-$  or  $O^{2-}$  on the platinum Pt and oxidized. Also, when the air-fuel ratio of the inflowing exhaust gas becomes rich, the oxygen concentration in the inflowing exhaust gas is extremely lowered, and therefore the  $NO_2$  is released from the absorbent, and this  $NO_2$  is reacted with the unburnt HC and CO and reduced as shown in Fig. 5B. In this way, when the  $NO_2$  no longer exists on the surface of the platinum Pt, the  $NO_2$  is successively released from the absorbent. Accordingly, this means that, when the air-fuel ratio of the inflowing exhaust gas is made rich,  $NO_x$  is released from the  $NO_x$  absorbent 19 in a short time.

[0021] Namely, when the air-fuel ratio of the inflowing exhaust gas is made rich, first of all, the unburnt HC and CO are immediately reacted with the  $O_2^-$  or  $O^{2-}$  on the platinum Pt and oxidized, and subsequently if the unburnt HC and CO still remain even if the  $O_2^-$  or  $O^{2-}$  on the platinum Pt are consumed, the  $NO_x$  released from the absorbent and the  $NO_x$  discharged from the engine are reduced by these unburnt HC and CO. Accordingly, when the air-fuel ratio of the inflowing exhaust gas is made rich, the  $NO_x$  absorbed in the  $NO_x$  absorbent 19 is released in a short time, and in addition, this released  $NO_x$  is reduced, and therefore this means that it is possible to prevent the discharge of  $NO_x$  into the atmosphere. Also, the  $NO_x$  absorbent 19 has a function of a reduction catalyst, and therefore even if the air-fuel ratio of the inflowing exhaust gas is made the stoichiometric

air-fuel ratio, the  $\text{NO}_x$  released from the  $\text{NO}_x$  absorbent 19 is reduced. However, where the air-fuel ratio of the inflowing exhaust gas is made the stoichiometric air-fuel ratio, the  $\text{NO}_x$  can be only gradually released from the  $\text{NO}_x$  absorbent 19, and therefore a slightly long time is required for releasing all  $\text{NO}_x$  absorbed in the  $\text{NO}_x$  absorbent 19.

[0022] When the degree of leanness of the air-fuel ratio of the inflowing exhaust gas is made low as mentioned before, even if the air-fuel ratio of the inflowing exhaust gas is lean, the  $\text{NO}_x$  is released from the  $\text{NO}_x$  absorbent 19. Accordingly, so as to release the  $\text{NO}_x$  from the  $\text{NO}_x$  absorbent 19, it is sufficient if the oxygen concentration in the inflowing exhaust gas is lowered. Note, if the air-fuel ratio of the inflowing exhaust gas is lean even though the  $\text{NO}_x$  is released from the  $\text{NO}_x$  absorbent 19, the  $\text{NO}_x$  is not reduced in the  $\text{NO}_x$  absorbent 19, and accordingly in this case, it is necessary to provide a catalyst which can reduce the  $\text{NO}_x$  on the downstream side of the  $\text{NO}_x$  absorbent 19 or feed the reduction agent to the downstream side of the  $\text{NO}_x$  absorbent 19. Of course, it is possible to reduce the  $\text{NO}_x$  on the downstream side of the  $\text{NO}_x$  absorbent 19 in this way, but it is rather preferred that the  $\text{NO}_x$  be reduced in the  $\text{NO}_x$  absorbent 19. Accordingly, when the  $\text{NO}_x$  should be released from the  $\text{NO}_x$  absorbent 19, it is more preferable that the air-fuel ratio of the inflowing exhaust gas be made the stoichiometric air-fuel ratio or rich.

[0023] As shown in Fig. 3, in the embodiment according to the present invention, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich at the time of the warm-up operation and at the time of full load operation and the air-fuel ratio of the air-fuel mixture is made the stoichiometric air-fuel ratio at the time of the acceleration operation, but in most of the operating region other than these, a lean air-fuel mixture is burned in the combustion chamber 3. In this case, the air-fuel ratio of the air-fuel mixture burned in the combustion chamber 3 is almost 18.0 or more, and in the embodiment shown in Fig. 1, a lean air-fuel mixture having an air-fuel ratio of about 20 to 24 is burned. When the air-fuel ratio becomes 18.0 or more, even if the three-way catalyst has a reduction property under a lean air-fuel ratio, it cannot sufficiently reduce the  $\text{NO}_x$ , and accordingly the three-way catalyst cannot be used for reducing the  $\text{NO}_x$  under such a lean air-fuel ratio. Also, there is a Cu - zeolite catalyst as a catalyst which can reduce the  $\text{NO}_x$  even if the air-fuel ratio is 18.0 or more, but this Cu - zeolite catalyst lacks heat resistance, and therefore it is not actually preferred that this Cu - zeolite catalyst be used. Accordingly, in the end, there is no way except that the  $\text{NO}_x$  absorbent 19 which has been used in the present invention be used for removing the  $\text{NO}_x$  when the air-fuel ratio is 18.0 or more.

[0024] In the embodiment according to the present invention, as mentioned above, at the time of the full load operation, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich, while at the time

of an acceleration operation, the air-fuel ratio of the air-fuel mixture is made the stoichiometric air-fuel ratio, and therefore this means that the  $\text{NO}_x$  is released from the  $\text{NO}_x$  absorbent 19 at the time of the full load operation and at the time of the acceleration operation. However, when the frequency of such a full load operation or acceleration operation being carried out is small, even if the  $\text{NO}_x$  is released from the  $\text{NO}_x$  absorbent 19 only at the time of the full load operation and the time of the acceleration operation, the absorption capability of  $\text{NO}_x$  by the  $\text{NO}_x$  absorbent 19 is saturated during a period when the lean air-fuel mixture is burned, and thus the  $\text{NO}_x$  can no longer be absorbed by the  $\text{NO}_x$  absorbent 19. Accordingly, when the lean air-fuel mixture is being continuously burned, it is necessary to periodically make the air-fuel ratio of the inflowing exhaust gas rich or periodically make the air-fuel ratio of the inflowing exhaust gas the stoichiometric air-fuel ratio and periodically release the  $\text{NO}_x$  from the  $\text{NO}_x$  absorbent 19.

[0025]  $\text{SO}_x$  is contained in the exhaust gas, and not only  $\text{NO}_x$ , but also  $\text{SO}_x$  are absorbed into the  $\text{NO}_x$  absorbent 19. It can be considered that the mechanism of the absorption of  $\text{SO}_x$  into the  $\text{NO}_x$  absorbent 19 is the same as the absorption mechanism of the  $\text{NO}_x$ .

[0026] Namely, when explaining this by taking as an example a case where platinum Pt and barium Ba are carried on the carrier in the same way as in the explanation of the absorption mechanism of  $\text{NO}_x$ , as mentioned before, when the air-fuel ratio of the inflowing exhaust gas is lean, the oxygen  $\text{O}_2$  is deposited on the surface of the platinum Pt in the form of  $\text{O}_2^-$  or  $\text{O}^{2-}$ , and the  $\text{SO}_x$  in the inflowing exhaust gas reacts with the  $\text{O}_2^-$  or  $\text{O}^{2-}$  on the surface of the platinum Pt and becomes  $\text{SO}_3$ . Subsequently, a part of the produced  $\text{SO}_3$  is further oxidized on the platinum Pt, while absorbed into the absorbent, and bonded with the barium oxide BaO, while diffused in the absorbent in the form of the sulfuric acid ion  $\text{SO}_4^{2-}$  to produce a stable sulfate  $\text{BaSO}_4$ .

[0027] However, this sulfate  $\text{BaSO}_4$  is stable and difficult to decompose, and even if the air-fuel ratio of the inflowing exhaust gas is made rich, the sulfate  $\text{BaSO}_4$  remains as it is without decomposition. Accordingly, as the time is elapsed, the sulfate  $\text{BaSO}_4$  is increased in the  $\text{NO}_x$  absorbent 19, and thus as time elapses, the amount of  $\text{NO}_x$  that can be absorbed by the  $\text{NO}_x$  absorbent 19 will be lowered.

[0028] Therefore, in the embodiment according to the present invention, so as to prevent the  $\text{SO}_x$  from flowing into the  $\text{NO}_x$  absorbent 19, an  $\text{SO}_x$  absorbent 18 which absorbs the  $\text{SO}_x$  when the air-fuel ratio of the inflowing exhaust gas is lean, while releases the absorbed  $\text{SO}_x$  when the air-fuel ratio of the inflowing exhaust gas becomes rich and, at the same time, has a function of the three-way catalyst, is arranged on the upstream side of the  $\text{NO}_x$  absorbent 19. This  $\text{SO}_x$  absorbent 18 absorbs also  $\text{NO}_x$  together with  $\text{SO}_x$  when the air-fuel ratio of the exhaust gas flowing into the  $\text{SO}_x$  absorbent 18 is lean, but releases not only the absorbed  $\text{NO}_x$ , but also the

absorbed  $\text{SO}_x$  when the air-fuel ratio of the exhaust gas flowing into the  $\text{SO}_x$  absorbent 18 is made rich.

[0029] As mentioned above, in the  $\text{NO}_x$  absorbent 19, when the  $\text{SO}_x$  is absorbed, a stable sulfate  $\text{BaSO}_4$  is formed, and as a result, even if the air-fuel ratio of the exhaust gas flowing into the  $\text{NO}_x$  absorbent 19 is made rich, the  $\text{SO}_x$  no longer will be released from the  $\text{NO}_x$  absorbent 19. Accordingly, so as to release the  $\text{SO}_x$  from the  $\text{SO}_x$  absorbent 18 when the air-fuel ratio of the exhaust gas flowing into the  $\text{SO}_x$  absorbent 18 is made rich, it becomes necessary to make the absorbed  $\text{SO}_x$  exist in the absorbent in the form of the sulfuric acid ion  $\text{SO}_4^{2-}$ , or to make the sulfate  $\text{BaSO}_4$  exist in the absorbent in an unstable state even if the sulfate  $\text{BaSO}_4$  is produced. As the  $\text{SO}_x$  absorbent 18 enabling this, use can be made of an absorbent which carries at least one member selected from a transition metal such as copper Cu, iron Fe, manganese Mn, and nickel Ni, sodium Na, tin Sn, titanium Ti, and lithium Li on a carrier made of alumina. In this case, it is clarified that the absorbent carrying the lithium Li on the carrier made of alumina is the most preferred.

[0030] In this  $\text{SO}_x$  absorbent 18, when the air-fuel ratio of the exhaust gas flowing into the  $\text{SO}_x$  absorbent 18 is lean, the  $\text{SO}_x$  contained in the exhaust gas is oxidized on the surface of the absorbent and absorbed into the absorbent in the form of the sulfuric acid ion  $\text{SO}_4^{2-}$  and then diffused in the absorbent. In this case, when the platinum Pt is caught on the carrier of the  $\text{SO}_x$  absorbent 18,  $\text{SO}_x$  becomes easily adhered onto the platinum Pt in the form of  $\text{SO}_3^{2-}$ , and thus the  $\text{SO}_2$  becomes easily absorbed into the absorbent in the form of the sulfuric acid ion  $\text{SO}_4^{2-}$ . Accordingly, so as to promote the absorption of the  $\text{SO}_2$ , preferably the platinum Pt is carried on the carrier of the  $\text{SO}_x$  absorbent 18. As mentioned above, when the air-fuel ratio of the exhaust gas flowing into the  $\text{SO}_x$  absorbent 18 becomes lean, the  $\text{SO}_x$  is absorbed into the  $\text{SO}_x$  absorbent 18, and accordingly only the  $\text{NO}_x$  is absorbed into the  $\text{NO}_x$  absorbent 19 provided on the downstream side of the  $\text{SO}_x$  absorbent 18.

[0031] On the other hand, as mentioned before, the  $\text{SO}_x$  absorbed in the  $\text{SO}_x$  absorbent 18 has been diffused in the absorbent in the form of the sulfuric acid ion  $\text{SO}_4^{2-}$ , or has become the sulfate  $\text{BaSO}_4$  in an unstable state. Accordingly, when the air-fuel ratio of the exhaust gas flowing into the  $\text{SO}_x$  absorbent 18 becomes rich, the  $\text{SO}_x$  absorbed in the  $\text{SO}_x$  absorbent 18 will be released from the  $\text{SO}_x$  absorbent 18. At this time, the  $\text{NO}_x$  is simultaneously released from the  $\text{NO}_x$  absorbent 19.

[0032] As mentioned before, when the  $\text{NO}_2$  on the surface of the platinum Pt no longer exists, in the  $\text{NO}_x$  absorbent 19, the reaction is immediately advanced in the direction of ( $\text{NO}_3^- \rightarrow \text{NO}_2$ ), and the  $\text{NO}_x$  is immediately released from the absorbent. When the air-fuel ratio of the exhaust gas flowing into the  $\text{NO}_x$  absorbent 19 is made rich, the  $\text{NO}_2$  on the surface of platinum Pt is immediately reduced by the unburnt HC and CO, and therefore the  $\text{NO}_2$  on the surface of the platinum Pt im-

mediately disappears, and thus, as shown in Fig. 6, the  $\text{NO}_x$  will be released from the  $\text{NO}_x$  absorbent in a short time. Namely, this means that the  $\text{NO}_x$  releasing speed of the  $\text{NO}_x$  absorbent 19 is considerably high.

[0033] Contrary to this, the  $\text{SO}_x$  absorbed in the  $\text{SO}_x$  absorbent 18 is difficult to decompose since it is more stable than the  $\text{NO}_x$  absorbed in the  $\text{NO}_x$  absorbent 19. The decomposition of this  $\text{SO}_x$  is not caused unless the air-fuel ratio of the exhaust gas flowing into the  $\text{SO}_x$  absorbent 18 is made rich. Namely, when the air-fuel ratio of the exhaust gas flowing into the  $\text{SO}_x$  absorbent 18 is made rich, the  $\text{SO}_x$  in the  $\text{SO}_x$  absorbent 18 is decomposed and released from the absorbent. This decomposition speed is considerably slow, and thus, as shown in Fig. 6, even if the air-fuel ratio of the inflowing exhaust gas to the  $\text{SO}_x$  absorbent 18 is made rich, a long time is required until the releasing of the  $\text{SO}_x$  is completed in comparison with  $\text{NO}_x$ . Namely, this means that the releasing speed of the  $\text{SO}_x$  is considerably slow in comparison with the releasing speed of the  $\text{NO}_x$ .

[0034] As mentioned before, when the  $\text{NO}_x$  should be released from the  $\text{NO}_x$  absorbent 19, preferably the air-fuel ratio of the inflowing exhaust gas is made the stoichiometric air-fuel ratio or rich. However, if the air-fuel ratio of the inflowing exhaust gas is not made rich, the  $\text{SO}_x$  is not released from the  $\text{SO}_x$  absorbent 18. Accordingly, in the embodiment according to the present invention, when the  $\text{SO}_x$  should be released from the  $\text{SO}_x$  absorbent 18 and the  $\text{NO}_x$  should be released from the  $\text{NO}_x$  absorbent 19, the air-fuel ratio of the inflowing exhaust gas is made rich.

[0035] When the air-fuel ratio of the inflowing exhaust gas is made rich, the  $\text{SO}_x$  is released from the  $\text{SO}_x$  absorbent 18, and the  $\text{NO}_x$  is released from the  $\text{NO}_x$  absorbent 19. However, if the  $\text{SO}_x$  released from the  $\text{SO}_x$  absorbent 18 flows into the  $\text{NO}_x$  absorbent 19 when the  $\text{NO}_2$  is being released from the  $\text{NO}_x$  absorbent 19, the  $\text{SO}_2$  and the  $\text{NO}_2$  are reacted in the  $\text{NO}_x$  absorbent 19 ( $\text{SO}_2 + \text{NO}_2 \rightarrow \text{SO}_3 + \text{NO}$ ), and thus the produced  $\text{SO}_3$  is absorbed into the  $\text{NO}_x$  absorbent 19 in the form of  $\text{SO}_4^{2-}$ . However, as mentioned before, the releasing speed of the  $\text{NO}_x$  is considerably slower than the releasing speed of the  $\text{SO}_x$  as shown in Fig. 6, and accordingly the most part of the  $\text{SO}_2$  released from the  $\text{SO}_x$  absorbent 18 flows into the  $\text{NO}_x$  absorbent 19 after the  $\text{NO}_x$  releasing action from the  $\text{NO}_x$  absorbent 19 is completed. Accordingly, the amount of  $\text{SO}_x$  absorbed into the  $\text{NO}_x$  absorbent 19 becomes small.

[0036] On the other hand, in the embodiment shown in Fig. 1, the releasing action of the  $\text{SO}_x$  from the  $\text{SO}_x$  absorbent 18 and the releasing action of the  $\text{NO}_x$  from the  $\text{NO}_x$  absorbent 19 are carried out when the predetermined amount of  $\text{NO}_x$  is absorbed into the  $\text{NO}_x$  absorbent 19, for example, the  $\text{NO}_x$  absorbent 19 absorbs the  $\text{NO}_x$  in an amount of 50 percent based on the total absorption capability of the same. The amount of the  $\text{NO}_x$  absorbed into the  $\text{NO}_x$  absorbent 19 is in proportion to the amount of the exhaust gas discharged from en-

engine and the  $\text{NO}_x$  concentration in the exhaust gas. In this case, the exhaust gas amount is in proportion to the intake air amount, and the concentration of  $\text{NO}_x$  in the exhaust gas is in proportion to the engine load, and therefore the amount of  $\text{NO}_x$  absorbed into the  $\text{NO}_x$  absorbent 19 becomes correctly in proportion to the intake air amount and engine load. Accordingly, the amount of the  $\text{NO}_x$  absorbed in the  $\text{NO}_x$  absorbent 19 can be estimated from the cumulative value of the product of the intake air amount and the engine load, but in the embodiment shown in Fig. 1, it is simplified and the amount of  $\text{NO}_x$  absorbed in the  $\text{NO}_x$  absorbent 19 is estimated from the cumulative value of the engine rotational speed.

[0037] Next, an explanation will be made of one embodiment of the absorption and releasing control of the  $\text{NO}_x$  absorbent 19 referring to Fig. 7 and Fig. 8.

[0038] Figure 7 shows an interruption routine executed at every predetermined time interval.

[0039] Referring to Fig. 7, first of all, at step 100, it is determined whether or not the correction coefficient K with respect to the basic fuel injection time TP is smaller than 1.0, that is, whether or not a lean air-fuel mixture is being burned. When  $K < 1.0$ , that is, when a lean air-fuel mixture is being burned, the processing routine goes to step 101, at which the result of addition of  $\Sigma\text{NE}$  to the current engine rotational speed NE is made  $\Sigma\text{NE}$ . Accordingly, this  $\Sigma\text{NE}$  indicates the cumulative value of the engine rotational speed NE. Subsequently, at step 102, it is determined whether or not the cumulative rotational speed  $\Sigma\text{NE}$  is larger than the constant value SNE. This constant value SNE indicates the cumulative rotational speed from which it is estimated that the  $\text{NO}_x$  in an amount of for example 50 percent based on the total  $\text{NO}_x$  absorption capability of the  $\text{NO}_x$  absorbent 19 has been absorbed in the  $\text{NO}_x$  absorbent 19. When  $\Sigma\text{NE} \leq \text{SNE}$ , the processing cycle is completed, while when  $\Sigma\text{NE} > \text{SNE}$ , that is, when it is estimated that the  $\text{NO}_x$  in an amount of 50 percent based on the total  $\text{NO}_x$  absorption capability of the  $\text{NO}_x$  absorbent 19 has been absorbed in the  $\text{NO}_x$  absorbent 19, the processing routine goes to step 103, at which the  $\text{NO}_x$  releasing flag is set. When the  $\text{NO}_x$  releasing flag is set, as will be mentioned later, the air-fuel ratio of the air-fuel mixture to be fed into the engine cylinder is made rich.

[0040] Subsequently, at step 104, the count value C is incremented exactly by one. Subsequently, at step 105, it is determined whether or not the count value C becomes larger than the constant value  $C_0$ , that is whether or not for example 5 seconds have elapsed. When  $C \leq C_0$ , the processing routine is completed, and when C becomes smaller than  $C_0$ , the processing routine goes to step 106, at which the  $\text{NO}_x$  releasing flag is reset. When the  $\text{NO}_x$  releasing flag is reset, as will be mentioned later, the air-fuel ratio of the air-fuel mixture fed into the engine cylinder is switched from rich to lean, and thus the air-fuel ratio of the air-fuel mixture fed into the engine cylinder is made rich for 5 seconds. Subse-

quently, at step 107, the cumulative rotational speed  $\Sigma\text{NE}$  and the count value C are made zero.

[0041] On the other hand, at step 100, when it is decided that  $K \geq 1.0$ , that is, when the air-fuel ratio of the air-fuel mixture being fed into the engine cylinder is the stoichiometric air-fuel ratio or rich, the processing routine goes to step 108, at which it is determined whether or not the state of  $K \geq 1.0$  is continued for the predetermined time, for example, 10 seconds. When the state of  $K \geq 1.0$  is not continued for the predetermined time, the processing cycle is completed, and when the state of  $K \geq 1.0$  is continued for the constant time, the processing routine goes to step 109, at which the cumulative rotational speed  $\Sigma\text{NE}$  is made zero.

[0042] Namely, when the time during which the air-fuel ratio of the air-fuel mixture fed into the engine cylinder is made the stoichiometric air-fuel ratio or rich continues for about 10 seconds, it is considered that the most part of the  $\text{SO}_x$  absorbed in the  $\text{SO}_x$  absorbent 18 was released and, at the same time, the most part of the  $\text{NO}_x$  absorbed in the  $\text{NO}_x$  absorbent 19 was released, and accordingly, in this case, the cumulative rotational speed  $\Sigma\text{NE}$  is made zero at step 109.

[0043] Figure 8 shows a calculation routine of the basic fuel injection time TAU, which routine is repeatedly executed.

[0044] Referring to Fig. 8, first, at step 200, the basic fuel injection time TP is calculated from the map shown in Fig. 2. Subsequently, at step 201, it is determined whether or not the operation state is that where the combustion of a lean air-fuel mixture should be carried out. When it is not the operation state where the combustion of a lean air-fuel mixture should be carried out, that is, at the time of the warm-up operation or the time of the acceleration operation or the time of the full load operation, the processing routine goes to step 202, at which the correction coefficient K is calculated. At the time of the engine warm-up operation, this correction coefficient K is a function of the engine coolant temperature and becomes smaller within the range where  $K \geq 1.0$  as the engine coolant temperature becomes higher. Also, at the time of the acceleration operation, the correction coefficient K is made 1.0, and at the time of the full load operation, the correction coefficient K is made a value larger than 1.0. Subsequently, at step 203, the correction coefficient K is made Kt, and then at step 204, the fuel injection time TAU ( $= \text{TP} \cdot \text{Kt}$ ) is calculated. At this time, the air-fuel ratio of the air-fuel mixture fed into the engine cylinder is made the stoichiometric air-fuel ratio or rich.

[0045] On the other hand, when it is determined at step 201 that it is the operation state where the combustion of a lean air-fuel mixture should be carried out, the processing routine goes to step 205, at which it is determined whether or not the  $\text{NO}_x$  releasing flag has been set. When the  $\text{NO}_x$  releasing flag has not been set, the processing routine goes to step 206, at which the correction coefficient K is made for example 0.6, and then



at step 207, after the correction coefficient K is made Kt, the processing routine goes to step 204. Accordingly, at this time, the lean air-fuel mixture is fed into the engine cylinder. On the other hand, when it is decided at step 205 that the NO<sub>x</sub> releasing flag is set, the processing routine goes to step 208, at which the predetermined value KK is made Kt, and then the processing routine goes to step 204. This value KK is a value of about 1.1 to 1.2 with which the air-fuel ratio of the air-fuel mixture fed into the engine cylinder becomes about 12.0 to 13.5. Accordingly, at this time, the rich air-fuel mixture is fed into the engine cylinder, whereby the SO<sub>x</sub> absorbed in the SO<sub>x</sub> absorbent 18 will be released and, at the same time, the NO<sub>x</sub> absorbed in the NO<sub>x</sub> absorbent 19 will be released.

[0046] Figure 9 shows another embodiment. In this embodiment, the same constituent elements as those shown in Fig. 1 are indicated by the same symbols.

[0047] As shown in Fig. 9, in this embodiment, an exhaust manifold 16 is connected to the inlet portion of a casing 41 containing an SO<sub>x</sub> absorbent 40, and the outlet portion of the casing 40 is connected via the exhaust pipe 42 to the inlet portion of a casing 44 containing an NO<sub>x</sub> absorbent 43. Also in this embodiment, when the lean air-fuel mixture is being burned in the combustion chamber 3, the SO<sub>x</sub> is absorbed into the SO<sub>x</sub> absorbent 40 and, at the same time, the NO<sub>x</sub> is absorbed into the NO<sub>x</sub> absorbent 43. On the other hand, when the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich, the SO<sub>x</sub> is released from the SO<sub>x</sub> absorbent 40, and the NO<sub>x</sub> is released from the NO<sub>x</sub> absorbent 43.

[0048] Figure 10 shows a case where the present invention is applied to a diesel engine. Note that, in Fig. 10, constituent elements the same as those shown in Fig. 1 are indicated by the same symbols.

[0049] In the diesel engine, usually in all operation states, combustion is performed in a state where an air excess rate is 1.0 or more, that is, the average air-fuel ratio of the air-fuel mixture in the combustion chamber 3 is lean. Accordingly, the SO<sub>x</sub> discharged at this time is absorbed into the SO<sub>x</sub> absorbent 18, and the NO<sub>x</sub> discharged at this time is absorbed into the NO<sub>x</sub> absorbent 19. On the other hand, when the SO<sub>x</sub> should be released from the SO<sub>x</sub> absorbent 18 and, at the same time, the NO<sub>x</sub> should be released from the NO<sub>x</sub> absorbent 19, the air-fuel ratio of the exhaust gas flowing into the SO<sub>x</sub> absorbent 18 and the NO<sub>x</sub> absorbent 19 is made rich. In this case, in the embodiment shown in Fig. 10, the average air-fuel ratio of the air-fuel mixture in the combustion chamber 3 is made lean and the hydrogen carbide is fed into the engine exhaust passage on the upstream side of the SO<sub>x</sub> absorbent 18, whereby the air-fuel ratio of the inflowing exhaust gas to the SO<sub>x</sub> absorbent 18 and the NO<sub>x</sub> absorbent 19 is made rich.

[0050] Referring to Fig. 10, in this embodiment, a load sensor 51 generating an output voltage in proportion to an amount of depression of an accelerator pedal 50 is

provided, and the output voltage of this load sensor 51 is input via the AD converter 52 to the input port 35. Also, in this embodiment, a reduction agent feeding valve 60 is arranged in an exhaust pipe 17, which reduction agent feeding valve 60 is connected via a feeding pump 61 to a reduction agent tank 62. The output port 36 of the electronic control unit 30 is connected via drive circuits 38 to the reduction agent feeding valve 60 and the feeding pump 61, respectively. In the reduction agent tank 62, a hydrocarbon such as gasoline, isooctane, hexane, heptane, light oil or a lamp oil, or a hydrocarbon which can be stored in a liquid state, for example, butane or propane is filled.

[0051] In this embodiment, the air-fuel mixture in the combustion chamber 3 is usually burned under an excess of air, that is, in a state where the average air-fuel ratio is lean. At this time, the SO<sub>x</sub> discharged from the engine is absorbed into the SO<sub>x</sub> absorbent 18 and, at the same time, the NO<sub>x</sub> discharged from the engine is absorbed into the NO<sub>x</sub> absorbent 19. When the SO<sub>x</sub> should be released from the SO<sub>x</sub> absorbent 18 and, at the same time the NO<sub>x</sub> should be released from the NO<sub>x</sub> absorbent 19, the feeding pump 61 is driven and, at the same time, the reduction agent feeding valve 60 is opened, whereby the hydrocarbon filled in the reduction agent tank 62 is fed from the reduction agent feeding valve 60 to the exhaust pipe 17 for a constant time, for example, about 5 seconds to 20 seconds. The amount of feeding of the hydrocarbon at this time is determined so that the air-fuel ratio of the inflowing exhaust gas flowing into the SO<sub>x</sub> absorbent 18 and the NO<sub>x</sub> absorbent 19 becomes rich, and accordingly, at this time, the SO<sub>x</sub> will be released from the SO<sub>x</sub> absorbent 18, and the NO<sub>x</sub> will be released from the NO<sub>x</sub> absorbent 19.

[0052] Figure 11 shows a routine for executing this NO<sub>x</sub> releasing processing, which routine is executed by interruption at every predetermined time interval.

[0053] Referring to Fig. 11, first of all, at step 300, the result of addition of  $\Sigma NE$  to the current engine rotational speed NE is made  $\Sigma NE$ . Accordingly, this  $\Sigma NE$  indicates the cumulative value of the engine rotational speed NE. Subsequently, at step 301, it is determined whether or not the cumulative rotational speed  $\Sigma NE$  is larger than the constant value SNE. This constant value SNE indicates the cumulative rotational speed from which it is estimated that the NO<sub>x</sub> in an amount of for example 50 percent based on the total NO<sub>x</sub> absorption capability of the NO<sub>x</sub> absorbent 19 has been absorbed in the NO<sub>x</sub> absorbent 19. When  $\Sigma NE \leq SNE$ , the processing cycle is completed, while when  $\Sigma NE > SNE$ , that is, when it is estimated that the NO<sub>x</sub> in an amount of 50 percent based on the total NO<sub>x</sub> absorption capability of the NO<sub>x</sub> absorbent 19 has been absorbed in the NO<sub>x</sub> absorbent 19, the processing routine goes to step 302, at which the feeding pump 61 is driven for a constant time, for example, for about 5 seconds to 20 seconds. Subsequently, at step 303, the reduction agent feeding valve 60 is opened for a constant time, for example, for about



5 seconds to 20 seconds, and then, at step 304, the cumulative rotational speed  $\Sigma NE$  is made zero.

[0054] Figure 12 shows a further embodiment. Note that, in Fig. 12, constituent elements the same as those shown in Fig. 1 are indicated by the same symbols.

[0055] Referring to Fig. 12, in this embodiment, a temperature sensor 22 is arranged in the exhaust pipe 17 on the upstream side of the casing 20. This temperature sensor 22 generates an output voltage in proportion to the exhaust gas temperature flowing in the exhaust pipe 17, and this output voltage is input to the input port 35 via the AD converter 37. Further, in this embodiment, a bidirectional bus 31 is connected to a backup RAM 33a always connected to the power source.

[0056] This embodiment prevents the  $SO_x$  released from the  $SO_x$  absorbent 18 from being absorbed into the  $NO_x$  absorbent 19 as much as possible. Note that, in this embodiment, the releasing control of the  $SO_x$  and  $NO_x$  is carried out considering also the temperature of the  $SO_x$  absorbent 18. Accordingly, first of all, an explanation will be made of a relationship between the temperature of the  $SO_x$  absorbent 18 and the releasing function of the  $SO_x$ .

[0057] Namely, the decomposition function of the  $SO_x$  absorbed in the  $SO_x$  absorbent 18 depends on the temperature of the  $SO_x$  absorbent 18, and the decomposition becomes more difficult as the temperature of the  $SO_x$  absorbent 18 becomes lower. Accordingly, as the temperature of the  $SO_x$  absorbent 18 becomes lower, the  $SO_x$  becomes harder to be decomposed unless the air-fuel ratio of the air-fuel mixture flowing into the  $SO_x$  absorbent 18 is made rich, and thus this means that the  $SO_x$  is not released from the  $SO_x$  absorbent 18. Figure 13 shows a relationship between the air-fuel ratio A/F of the inflowing exhaust gas with which the  $SO_x$  absorbent 18 can release the  $SO_x$  and the temperature T of the  $SO_x$  absorbent 18. It is seen from Fig. 13 that, so as to release the  $SO_x$ , the air-fuel ratio of the exhaust gas flowing into the  $SO_x$  absorbent 18 must be made richer as the temperature T of the  $SO_x$  absorbent 18 becomes lower.

[0058] Also in this embodiment, when the  $NO_x$  and  $SO_x$  should be released, the air-fuel mixture fed into the combustion chamber 3 is periodically made rich, and Fig. 14 shows a timing at which the air-fuel ratio of the air-fuel mixture is made rich in this way. Note that, in Fig. 14, P indicates a timing at which the  $NO_x$  is released from the  $NO_x$  absorbent 19, and Q indicates a timing at which the  $SO_x$  is released from the  $SO_x$  absorbent 18. As seen from Fig. 14, so as to release the  $NO_x$  from the  $NO_x$  absorbent 19, the period for which the air-fuel ratio of the air-fuel mixture is made rich is considerably short, and the air-fuel ratio of air-fuel mixture is made rich with a proportion of one time per several minutes. On the other hand, the amount of  $SO_x$  contained in the exhaust gas is considerably smaller in comparison with the amount of  $NO_x$ , and therefore a considerably long time is taken until the  $SO_x$  absorbent 18 is saturated by the

$SO_x$ . Accordingly, the period for which the air-fuel ratio of air-fuel mixture is made rich so as to release the  $SO_x$  from the  $SO_x$  absorbent 18 is considerably long, for example, the air-fuel ratio of air-fuel mixture is made rich with a proportion of one time per several hours.

[0059] As shown in Fig. 6, when the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich, the  $NO_x$  is released from the  $NO_x$  absorbent 19 in a short time, but a considerably long time is required until the  $SO_x$  is released from the  $SO_x$  absorbent 18. Accordingly, in this embodiment, a time for which the air-fuel ratio of air-fuel mixture is continuously made rich so as to release the  $SO_x$  is made considerably longer than the time for which the air-fuel ratio of air-fuel mixture is continuously made rich so as to release the  $NO_x$ . For example, in contrast to a fact that the air-fuel ratio of air-fuel mixture is made rich for about several seconds when the  $NO_x$  is to be released, the air-fuel ratio of air-fuel mixture is made rich for about several minutes when the  $SO_x$  is to be released. In this way, the air-fuel ratio of air-fuel mixture is made rich over a long time when the  $SO_x$  is released, but as mentioned above, a period for which the air-fuel ratio of air-fuel mixture is made rich for the release of the  $SO_x$  is long, and therefore a great increase of the fuel consumption amount will not be caused by this.

[0060] Figure 15 shows a rich control of the air-fuel mixture when releasing the  $NO_x$  (P of Fig. 14). Note that, Kt indicates the correction coefficient with respect to the basic fuel injection time TP.

[0061] As shown in Fig. 15, when the  $NO_x$  should be released from the  $NO_x$  absorbent 19, the air-fuel ratio of the air-fuel mixture air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich by increasing the correction coefficient Kt up to KK ( $> 1.0$ ), and then maintained at this rich state only for the time  $C_1$ . Subsequently, the correction coefficient Kt is gradually reduced, and then the correction coefficient Kt is maintained at 1.0, that is, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is maintained at the stoichiometric air-fuel ratio. Subsequently, when the time  $C_2$  has elapsed when the rich control is started, the correction coefficient Kt is made smaller than 1.0 again, and the combustion of the lean air-fuel mixture is started again.

[0062] When the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes rich ( $Kt = KK$ ), the most part of the  $NO_x$  absorbed in the  $NO_x$  absorbent 19 is abruptly released. The value of the correction coefficient KK and the time  $C_1$  are determined so as to generate the unburnt HC and CO in an amount necessary for consuming the  $O_2$  or  $O_2^-$  on the surface of the platinum Pt and reducing the whole  $NO_x$  at this time. In this case, as the exhaust gas temperature becomes higher and the temperature of the  $NO_x$  absorbent 19 becomes higher, the amount of the  $NO_x$  released from the  $NO_x$  absorbent 19 is increased. Accordingly, as shown in Fig. 16A, the value of the correction coefficient

cient KK is made larger as the exhaust gas temperature T becomes higher, and as shown in Fig. 16B, the time  $C_1$  is made shorter as the exhaust gas temperature T becomes higher. Note that, a relationship between the correction coefficient KK and the exhaust gas temperature T shown in Fig. 16A and the relationship between the time  $C_1$  and the exhaust gas temperature T shown in Fig. 16B are stored in advance in the ROM 32.

[0063] On the other hand, as mentioned before, when the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes rich ( $Kt = KK$ ), the most part of the  $NO_x$  absorbed in the  $NO_x$  absorbent 19 is abruptly released, and thereafter even if the air-fuel ratio has been made rich, the  $NO_x$  is released from the  $NO_x$  absorbent 19 only little by little. Accordingly, when the air-fuel ratio is continuously made rich, the unburnt HC and CO will be released into the atmosphere. Therefore, in this embodiment, as shown in Fig. 15, after the air-fuel ratio is made rich ( $Kt = KK$ ), the degree of richness is made gradually smaller, and subsequently the air-fuel ratio is maintained at the stoichiometric air-fuel ratio ( $Kt = 1.0$ ), and the  $NO_x$  gradually released from the  $NO_x$  absorbent 18 is sequentially reduced.

[0064] Note that, as the amount of the  $NO_x$  released from the  $NO_x$  absorbent 19 is larger when the air-fuel ratio is made rich, the amount of the  $NO_x$  released from the  $NO_x$  absorbent 19 becomes smaller, and accordingly a time until the  $NO_x$  absorbent 19 ends releasing  $NO_x$  becomes short. As mentioned before, as the exhaust gas temperature T becomes higher, the amount of the  $NO_x$  released from the  $NO_x$  absorbent 19 becomes larger when the air-fuel ratio is made rich, and accordingly, as shown in Fig. 16C, a time  $C_2$  of from when the air-fuel ratio is made rich to when it is returned to lean again is made shorter as the exhaust gas temperature T becomes higher. Note that, a relationship between the time  $C_2$  and the exhaust gas temperature T shown in Fig. 16C is stored in advance in the ROM 32.

[0065] In this way, KK,  $C_1$ , and  $C_2$  are controlled in accordance with the exhaust gas temperature T, and when the exhaust gas temperature T is high, the correction coefficient Kt is changed with a pattern indicated by a solid line of Fig. 15, and changed with a pattern indicated by a broken line of Fig. 15 when the exhaust gas temperature T is low. Note that, in this case, a time for which the air-fuel ratio of air-fuel mixture is rich is short, and therefore almost no  $SO_x$  is released from the  $SO_x$  absorbent 18, and substantially only the  $NO_x$  releasing action from the  $NO_x$  absorbent 19 is carried out.

[0066] Figure 17 shows the rich control of the air-fuel mixture when the  $SO_x$  is released (Q in Fig. 14).

[0067] As shown in Fig. 17, even when the  $SO_x$  should be released from the  $SO_x$  absorbent 18, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich by increasing the correction coefficient Kt up to KK ( $>1.0$ ), and then maintained at this rich state only for the time  $C_1$ . Subsequently, the correction coefficient Kt is gradually reduced, and then the correction

coefficient Kt is maintained at  $Ko (>1.0)$ , that is the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is continuously maintained rich. Namely, when the  $SO_x$  should be released, first of all, the air-fuel ratio of air-fuel mixture is made very rich up to the first degree of richness ( $Kt = KK$ ), and thereafter maintained at a second degree of richness ( $Kt = Ko$ ) smaller than this first degree of richness ( $Kt = KK$ ). Subsequently, when the time  $C_2$  has elapsed when the rich control is started, the correction coefficient Kt is made smaller than 1.0 again, and the combustion of the lean air-fuel mixture is started again. Note that, the time  $C_2$  when the  $SO_x$  is released is considerably longer in comparison with the time  $C_1$  at the time of releasing of the  $NO_x$  shown in Fig. 15 and for example is about 3 minutes to 10 minutes.

[0068] As mentioned before, the  $SO_x$  releasing speed from the  $SO_x$  absorbent 18 is considerably slow, and accordingly even if the air-fuel ratio of the air-fuel mixture is continuously made rich, the releasing of the  $SO_x$  cannot be completed in a short time. Namely, making the air-fuel ratio of the air-fuel mixture very rich leads to only an increase of the fuel consumption amount. Accordingly, when the  $SO_x$  should be released, the air-fuel ratio of the air-fuel mixture is maintained at the lowest degree of richness with which the  $NO_x$  can be released well, and this lowest degree of richness is indicated by  $Ko$  in Fig. 17. Accordingly, if the correction coefficient Kt is maintained at  $Ko$ , the  $SO_x$  will be released well from the  $SO_x$  absorbent 18. When the  $SO_x$  should be released irrespective of this, first of all, the air-fuel ratio of air-fuel mixture is made very rich ( $Kt = KK$ ). The reason for this will be explained next.

[0069] If the correction coefficient Kt is maintained at  $Ko$  when the  $SO_x$  should be released, the  $SO_x$  is gradually released from the  $SO_x$  absorbent 18. At this time, the  $NO_x$  is simultaneously released from the  $NO_x$  absorbent 19, but the degree of richness is small, and therefore the  $NO_x$  is gradually released also from the  $NO_x$  absorbent 19. However, if the  $SO_x$  released from the  $SO_x$  absorbent 18 is flowing into the  $NO_x$  absorbent 19 when the  $NO_x$  is gradually released from the  $NO_x$  absorbent 19 in this way, as mentioned before, the  $NO_2$  and  $SO_2$  react with each other ( $SO_2 + NO_2 \rightarrow SO_3 + NO$ ), and thus the produced  $SO_3$  will be absorbed into the  $NO_x$  absorbent 19 in the form of  $SO_4$ . Such a reaction is not caused so far as the  $NO_2$  does not exist, and accordingly so as to prevent the  $SO_2$  from absorption into the  $NO_x$  absorbent 19, it is necessary to prevent the  $NO_2$  from releasing from the  $NO_x$  absorbent 19 when the  $SO_x$  is being released from the  $SO_x$  absorbent 18. For this purpose, as shown in Fig. 17, when the  $SO_x$  should be released, first of all the air-fuel ratio of the air-fuel mixture is made very rich ( $Kt = KK$ ).

[0070] Namely, when the air-fuel ratio of the air-fuel mixture is made very rich ( $Kt = KK$ ), the most part of the  $NO_2$  is released from the  $NO_x$  absorbent 19 at one time, and thereafter almost no  $NO_2$  is released from the  $NO_x$

absorbent 19. Accordingly, thereafter the  $\text{SO}_2$  released from the  $\text{SO}_x$  absorbent 18 will not react with the  $\text{NO}_x$  when the correction coefficient  $K_t$  is maintained at  $K_o$ , and thus a risk of absorption of the  $\text{SO}_2$  into the  $\text{NO}_x$  absorbent 19 is eliminated.

[0071] As mentioned before, when the air-fuel ratio of the air-fuel mixture becomes rich ( $K_t = K_K$ ), the most part of the  $\text{NO}_x$  absorbed in the  $\text{NO}_x$  absorbent 19 is abruptly released, and at this time, as the exhaust gas temperature is higher, and accordingly the temperature of the  $\text{NO}_x$  absorbent 19 is higher, the amount of the  $\text{NO}_x$  released from the  $\text{NO}_x$  absorbent 19 is increased. Accordingly, as shown in Fig. 18A, the value of the correction coefficient  $K_K$  is made larger as the exhaust gas temperature  $T$  becomes higher, and as shown in Fig. 18B, the time  $C_1$  is made shorter as the exhaust gas temperature  $T$  becomes higher. Note that, a relationship between the correction coefficient  $K_K$  and the exhaust gas temperature  $T$  shown in Fig. 18A and the relationship between the time  $C_1$  and the exhaust gas temperature  $T$  shown in Fig. 18B are stored in advance in the ROM 32.

[0072] On the other hand, after the air-fuel ratio of the air-fuel mixture is made very rich ( $K_t = K_K$ ), it is maintained at a relatively small degree of richness ( $K_t = K_o$ ), and at this time, the  $\text{SO}_x$  is continuously released from the  $\text{SO}_x$  absorbent 18. At this time, as shown in Fig. 13, as the temperature of the  $\text{SO}_x$  absorbent 18, that is the exhaust gas temperature  $T$  becomes higher, the  $\text{SO}_x$  can be continuously released even if the air-fuel ratio  $A/F$  of the air-fuel mixture is lowered. Accordingly, in this embodiment, as the exhaust gas temperature  $T$  becomes higher, the air-fuel ratio  $A/F$  of the air-fuel mixture is made smaller. Namely, when the exhaust gas temperature  $T$  is high, as indicated by a solid line in Fig. 17, the value of  $K_o$  is made relatively small, and when the exhaust gas temperature  $T$  is low, as indicated by a broken line in Fig. 17, the value of  $K_o$  is made relatively large. Figure 18C shows a relationship between this value of  $K_o$  and the exhaust gas temperature  $T$ , which relationship is stored in advance in the ROM 32.

[0073] Note that, as the amount of the  $\text{SO}_x$  released from the  $\text{SO}_x$  absorbent 18 is larger when the air-fuel ratio of the air-fuel mixture is maintained rich ( $K_t = K_o$ ), a time until the  $\text{SO}_x$  absorbent 18 terminates the release of  $\text{SO}_x$  becomes shorter. As mentioned before, as the exhaust gas temperature  $T$  becomes higher, the decomposition speed of  $\text{SO}_x$  becomes faster, and the releasing speed of  $\text{SO}_x$  becomes faster, and accordingly, as shown in Fig. 18D, a time  $C_2$  from when the air-fuel ratio is made rich to when it is returned to lean again is made shorter as the exhaust gas temperature  $T$  becomes higher. Note that, a relationship between the time  $C_2$  and the exhaust gas temperature  $T$  shown in Fig. 18D is stored in advance in the ROM 32.

[0074] As shown in Figs. 16A to 16C and Figs. 18A to 18D, the various values  $K_K$ ,  $C_1$ ,  $K_o$ , and  $C_2$  are functions of the exhaust gas temperature  $T$ , and in this embodi-

ment, this exhaust gas temperature  $T$  is detected by the temperature sensor 22. In this way, it is also possible to directly detect the exhaust gas temperature  $T$ , but it is also possible to estimate the same from the intake air amount  $Q$  and the engine rotational speed  $N$ . In this case, it is sufficient if the relationship among the exhaust gas temperature  $T$ , the intake air amount  $Q$ , and the engine rotational speed  $N$  is found in advance from experiments and this relationship is stored in advance in the ROM 32 in the form of a map as shown in Fig. 19 and the exhaust gas temperature  $T$  is calculated from this map.

[0075] Next, the absorption and releasing control of the  $\text{NO}_x$  and  $\text{SO}_x$  will be explained referring to Fig. 20 to Fig. 22.

[0076] Figure 20 and Fig. 21 show a calculation routine of the correction coefficient  $K_K$  at the time of rich control, which routine is executed by interruption at every predetermined time interval.

[0077] Referring to Fig. 20 and Fig. 21, first of all, it is determined at step 400 whether or not the correction coefficient  $K$  is smaller than 1.0, that is, whether or not the lean air-fuel mixture is being burned. When  $K < 1.0$ , that is, when the lean air-fuel mixture is being burned, the processing routine goes to step 401, at which the amount  $W_n$  of  $\text{NO}_x$  absorbed in the absorbent 19 is calculated. Namely, the amount of  $\text{NO}_x$  discharged from the combustion chamber 3 is increased as the intake air amount  $Q$  becomes larger, and increased as the engine load  $Q/N$  becomes higher, and therefore the amount  $W_n$  of the  $\text{NO}_x$  absorbed in the  $\text{NO}_x$  absorbent 19 will be represented by the sum of  $W_n$  and  $K_1 \cdot Q \cdot Q/N$  ( $k_1$  is a constant).

[0078] Subsequently, at step 402, the amount  $W_s$  of the  $\text{SO}_x$  absorbed in the  $\text{SO}_x$  absorbent 18 is calculated. Namely, the amount of  $\text{SO}_x$  discharged from the combustion chamber 3 is increased as the intake air amount  $Q$  becomes larger, and therefore the amount  $W_n$  of the  $\text{SO}_x$  absorbed in the  $\text{SO}_x$  absorbent 18 will be represented by the sum of  $W_n$  and  $K_2 \cdot Q$  ( $k_2$  is a constant). This  $\text{SO}_x$  amount  $W_s$  is stored in the backup RAM 33a. Subsequently, at step 403, it is determined whether or not the  $\text{SO}_x$  releasing flag indicating that the  $\text{SO}_x$  should be released has been set. When the  $\text{SO}_x$  releasing flag has not been set, the processing routine goes to step 404, at which it is determined whether or not the  $\text{NO}_x$  releasing flag indicating that the  $\text{NO}_x$  should be released has been set. When the  $\text{NO}_x$  releasing flag has not been set, the processing routine goes to step 405.

[0079] At step 405, it is determined whether or not the amount  $W$  of the  $\text{SO}_x$  absorbed in the  $\text{SO}_x$  absorbent 18 is larger than the predetermined set up amount  $W_{so}$ . This set up amount  $W_{so}$  is for example about 30 percent based on the maximum amount of  $\text{SO}_x$  that can be absorbed by the  $\text{SO}_x$  absorbent 18. When  $W_s \leq W_{so}$ , the processing routine goes to step 411. At step 411, it is determined whether or not the amount  $W_n$  of the  $\text{NO}_x$  absorbed in the  $\text{NO}_x$  absorbent 19 is larger than the pre-

determined set amount  $W_{no}$ . This set amount  $W_{so}$  is for example about 30 percent based on the maximum amount of  $NO_x$  that can be absorbed by the  $NO_x$  absorbent 19. When  $W_n \leq W_{no}$ , the processing cycle is completed.

[0080] On the other hand, when it is determined at step 405 that  $W_s > W_{so}$ , the processing routine goes to step 406, at which the  $SO_x$  releasing flag is set. Subsequently, at step 407, the correction coefficient  $KK$  is calculated from the relationship shown in Fig. 18A, and then at step 408, the time  $C_1$  is calculated from the relationship shown in Fig. 18B. Subsequently, at step 409, the correction coefficient  $KK$  is calculated from the relationship shown in Fig. 18C, and then at step 410, the time  $C_2$  is calculated from the relationship shown in Fig. 18D. Subsequently, the processing cycle is completed. Note that, when the  $SO_x$  releasing flag is set and various values  $KK$ ,  $C_1$ ,  $K_o$ , and  $C_2$  are calculated, as will be mentioned later, the air-fuel ratio of air-fuel mixture is made rich.

[0081] On the other hand, when it is determined that  $W_n > W_{no}$  at step 411, the processing routine goes to step 412, at which the  $NO_x$  releasing flag is set. Subsequently, at step 413, the correction coefficient  $KK$  is calculated from the relationship shown in Fig. 16A, and then at step 414, the time  $C_1$  is calculated from the relationship shown in Fig. 16B. Subsequently, at step 415, the correction coefficient  $K_o$  is made 1.0, and then at step 416, the time  $C_2$  is calculated from the relationship shown in Fig. 16C. Subsequently, the processing cycle is completed. Note that, when the  $NO_x$  releasing flag is set and various values  $KK$ ,  $C_1$ ,  $K_o$ , and  $C_2$  are calculated, as will be mentioned later, the air-fuel ratio of air-fuel mixture is made rich.

[0082] When the  $SO_x$  releasing flag or the  $NO_x$  releasing flag is set, the processing routine goes from step 403 or step 404 to step 417, at which the count value  $C$  is incremented exactly by one. Subsequently, at step 418, it is determined whether or not the count value  $C$  is smaller than the time  $C_1$ . When  $C < C_1$ , the processing cycle is completed, and accordingly the correction coefficient is maintained at  $KK$  as it is for the time  $C_1$ . Subsequently, when  $C$  becomes equal to or larger than  $C_1$ , the processing routine goes to step 419, at which it is determined whether or not the count value  $C$  is smaller than the time  $C_2$ . When  $C < C_2$ , the processing routine goes to step 420, at which the predetermined value  $\alpha$  is subtracted from the correction coefficient  $KK$ . Accordingly, the value of the correction coefficient  $KK$  becomes gradually smaller.

[0083] Subsequently, at step 421, it is determined whether or not the correction coefficient  $KK$  has become smaller than  $K_o$ . When  $KK > K_o$ , the processing cycle is completed, and when  $KK$  becomes equal to or smaller than  $K_o$ , the processing routine goes to step 422, at which  $KK$  is made  $K_o$ . Accordingly, after when  $KK$  becomes equal to  $K_o$ , at the time of the releasing of  $SO_x$ , the correction coefficient is maintained at  $K_o$  ( $> 1.0$ ),

while at the time of the releasing of  $NO_x$ , the correction coefficient is maintained at 1.0.

[0084] Subsequently, when it is decided at step 419 that  $C$  becomes equal to or larger than  $C_2$ , the processing routine goes to step 423, at which it is determined whether or not the  $SO_x$  releasing flag has been set. When the  $SO_x$  releasing flag has been set, the processing routine goes to step 424, at which the  $SO_x$  releasing flag is reset. When the  $SO_x$  releasing flag is reset, as will be mentioned later, the combustion of the lean air-fuel mixture is started again. Subsequently, at step 425, the amount  $W_s$  of the  $SO_x$  absorbed in the  $SO_x$  absorption 18 is made zero, and then at step 427, the amount  $W_n$  of the  $NO_x$  absorbed in the  $NO_x$  absorption 19 is made zero. Subsequently, at step 428, the count value  $C$  is made zero.

[0085] On the other hand, at step 423, when it is decided that the  $SO_x$  releasing flag has not been set, the processing routine goes to step 426, at which the  $NO_x$  releasing flag is reset. When the  $NO_x$  releasing flag is reset, as will be mentioned later, the combustion of the lean air-fuel mixture is started again. Subsequently, at step 427, the amount  $W_n$  of the  $NO_x$  absorbed in the  $NO_x$  absorption 19 is made zero. Subsequently, at step 428, the count value  $C$  is made zero.

[0086] On the other hand, when it is decided at step 50 that  $K$  is equal to or larger than 1.0, that is, when the air-fuel ratio of the air-fuel mixture fed into the engine cylinder is the stoichiometric air-fuel ratio or rich, the processing routine goes to step 429, at which it is determined whether or not the state of  $K \geq 1.0$  continues for the predetermined time  $t_1$ , for example 10 seconds. When the state of  $K \geq 1.0$  does not continue for the predetermined time  $t_1$ , the processing cycle is completed, and when the state of  $K \geq 1.0$  continues for the predetermined time  $t_1$ , the processing routine goes to step 430, at which  $W_n$  is made zero. Namely, when the time for which air-fuel ratio of the air-fuel mixture fed into the engine cylinder is made the stoichiometric air-fuel ratio or rich continues for about 10 seconds, it is considered that the most part of the  $NO_x$  absorbed in the  $NO_x$  absorbent 19 was released, and accordingly, in this case,  $W_n$  is made zero at step 430.

[0087] Subsequently, at step 431, it is determined whether or not the state of  $K > 1.0$  continues for the predetermined time  $t_2$  ( $t_2 > t_1$ ), for example, 10 minutes. When the state of  $K > 1.0$  does not continue for the predetermined time  $t_2$ , the processing cycle is completed, and when the state of  $K > 1.0$  continues for the predetermined time  $t_2$ , the processing routine goes to step 432, at which  $W_s$  is made zero. Namely, when the time for which air-fuel ratio of the air-fuel mixture fed into the engine cylinder is made rich continues for about 10 minutes, it is considered that the most part of the  $SO_x$  absorbed in the  $SO_x$  absorbent 18 was released, and accordingly, in this case,  $W_s$  is made zero at step 432.

[0088] Figure 22 shows the calculation routine of the basic fuel injection time  $TAU$ , which routine is repeatedly

executed.

[0089] Referring to Fig. 22, first of all, at step 500, the correction coefficient K is calculated. This correction coefficient K is made for example 0.6 at the time of an operation state when the lean air-fuel mixture should be burned. Also, this correction coefficient K has become the function of the engine coolant temperature at the time of the engine warm-up operation and is made smaller as the engine coolant temperature becomes higher within a range where  $K \geq 1.0$ . Also, at the time of acceleration operation, this correction coefficient is made 1.0, and at the time of full load operation, this correction coefficient K is made a larger value than 1.0.

[0090] Subsequently, at step 501, it is determined whether or not the correction coefficient K is smaller than 1.0. When  $K \geq 1.0$ , the processing routine goes to step 505, at which K is made Kt. Contrary to this, when  $K < 1.0$ , the processing routine goes to step 502, at which it is determined whether or not the  $SO_x$  releasing flag has been set. When the  $SO_x$  releasing flag has not been set, the processing routine goes to step 503, at which it is determined whether or not the  $NO_x$  releasing flag has been set. When the  $NO_x$  releasing flag has not been set, the processing routine goes to step 505. Subsequently, at step 506, the basic fuel injection time TP is calculated from the map shown in Fig. 2, and then at step 507, the basic fuel injection time TAU ( $= TP \cdot Kt$ ) is calculated. Accordingly, when neither of the  $SO_x$  releasing flag nor  $NO_x$  releasing flag has been set even when  $K \geq 1.0$  or  $K < 1.0$ , the air-fuel ratio of the air-fuel mixture is made the air-fuel ratio in accordance with the correction coefficient K.

[0091] On the other hand, when the  $SO_x$  releasing flag or the  $NO_x$  releasing flag is set, the processing routine goes from step 502 or step 503 to step 504, at which Kt is made KK calculated by the routine shown in Fig. 20 and Fig. 21. Subsequently, the processing routine passes step 506, and the basic fuel injection time TAU is calculated at step 507. Accordingly, at this time, the air-fuel ratio of the air-fuel mixture is forcibly made rich.

[0092] Figure 23 shows a still further embodiment. Note that, in this embodiment, the same constituent elements as those shown in Fig. 1 and Fig. 12 are indicated by the same symbols.

[0093] Referring to Fig. 23, in this embodiment, the exhaust port 8 is connected via the exhaust manifold 16 to the casing 23 containing the  $SO_x$  absorbent 18, and the outlet portion of the casing 23 is connected via the exhaust pipe 17 to the casing 20 containing the  $NO_x$  absorbent 19. A bypass passage 24 is branched from the inlet portion 20a of the casing 20, and this bypass passage 24 is connected to the exhaust pipe 25 connected to the outlet portion of the casing 20. A switch valve 27 controlled by an actuator 26 is arranged at the branch portion of the bypass passage 24 from the inlet portion 20a of the casing 20. This switch valve 27 is controlled by the actuator 26 to either position between a bypass closed position at which the inlet portion of the bypass

passage 24 is closed and the inlet portion to the  $NO_x$  absorbent 19 is fully opened as indicated by the solid line in Fig. 23 and a bypass opening position at which the inlet portion to the  $NO_x$  absorbent 19 is closed and the inlet portion of the bypass passage 24 is fully opened as indicated by a broken line of Fig. 23.

[0094] Also, in this embodiment, a pressure sensor 28 generating an output voltage in proportion to the absolute pressure in the surge tank 10 is attached to the interior of the surge tank 10, and the output voltage of this pressure sensor 28 is input to the input port 35 via the AD converter 37.

[0095] Also in this embodiment, the fuel injection time TAU is calculated based on for example the following equation.

$$TAU = TP \cdot K$$

[0096] Here, TP indicates the basic fuel injection time, and K indicates the correction coefficient. The basic fuel injection time TP indicates a fuel injection time necessary for making the air-fuel ratio of the air-fuel mixture fed into the engine cylinder the stoichiometric air-fuel ratio. This basic fuel injection time TP is found in advance by experiments and stored in advance in the ROM 32 in the form of a map as shown in Fig. 24 as the functions of the absolute pressure PM of the surge tank 10 expressing the engine load and the engine rotational speed N. The correction coefficient K is a coefficient for controlling the air-fuel ratio of the air-fuel mixture fed into the engine cylinder, and if  $K = 1.0$ , the air-fuel ratio of the air-fuel mixture fed into the engine cylinder becomes the stoichiometric air-fuel ratio. Contrary to this, when K becomes smaller than 1.0, the air-fuel ratio of the air-fuel mixture fed into the engine cylinder becomes larger than the stoichiometric air-fuel ratio, that is, becomes lean, and if K becomes larger than 1.0, the air-fuel ratio of the air-fuel mixture fed into the engine cylinder becomes smaller than the stoichiometric air-fuel ratio, that is, becomes rich.

[0097] The value of this correction coefficient K is determined in advance with respect to the absolute pressure PM in the surge tank 10 and the engine rotational speed N, and Fig. 25 shows one embodiment of the value of this correction coefficient K. In the embodiment shown in Fig. 25, in a region in which the absolute pressure PM inside the surge tank 10 is relatively low, that is, in the engine low or medium load operation region, the value of the correction coefficient K is made a value smaller than 1.0, and accordingly, at this time, the air-fuel ratio of the air-fuel mixture fed into the engine cylinder is made lean. On the other hand, in a region in which the absolute pressure PM inside the surge tank 10 is relatively high, that is, in the engine high load operation region, the value of the correction coefficient K is made 1.0, and accordingly, at this time, the air-fuel ratio of the air-fuel mixture fed into the engine cylinder

is made the stoichiometric air-fuel ratio. Also, in a region in which the absolute pressure PM inside the surge tank 10 becomes the highest, that is, in the engine full load operation region, the value of the correction coefficient K is made a value larger than 1.0, and accordingly, at this time, the air-fuel ratio of the air-fuel mixture fed into the engine cylinder is made rich. In the internal combustion engine, usually the frequency of low and medium load operation is the highest, and accordingly in the most part of the operation period, the lean air-fuel mixture will be burned.

[0098] Also in this embodiment, as the SO<sub>x</sub> absorbent 18, use is made of an absorbent which carries at least one member selected from a transition metal such as copper Cu, iron Fe, manganese Mn, and nickel Ni, sodium Na, tin Sn, titanium Ti, and lithium Li on a carrier made of alumina. Note that, in this SO<sub>x</sub> absorbent 18, as mentioned before, when the air-fuel ratio of the exhaust gas flowing into the SO<sub>x</sub> absorbent 18 is lean, the SO<sub>2</sub> contained in the exhaust gas is oxidized on the surface of the absorbent while absorbed into the absorbent in the form of sulfuric acid ion SO<sub>4</sub><sup>2-</sup>, and in this case, when the platinum Pt is carried on the carrier of the SO<sub>x</sub> absorbent 18, SO<sub>2</sub> becomes easily adhered onto the platinum Pt in the form of SO<sub>3</sub><sup>2-</sup>, and thus the SO<sub>2</sub> becomes easily absorbed into the absorbent in the form of the sulfuric acid ion SO<sub>4</sub><sup>2-</sup>. Accordingly, so as to promote the absorption of the SO<sub>2</sub>, preferably the platinum Pt is carried on the carrier of the SO<sub>x</sub> absorbent 18.

[0099] Next, a detailed explanation will be made again of the NO<sub>x</sub> releasing function from the NO<sub>x</sub> absorbent 19 and the SO<sub>x</sub> releasing function from the SO<sub>x</sub> absorbent 18 referring to Figs. 26A and 26B. Figure 26A shows a relationship between the temperature T of the NO<sub>x</sub> absorbent 19 and the SO<sub>x</sub> absorbent 18 when the air-fuel ratio of the exhaust gas flowing into the SO<sub>x</sub> absorbent 18 and the NO<sub>x</sub> absorbent 19 is made rich, the NO<sub>x</sub> releasing rate f(T) from the NO<sub>x</sub> absorbent 19, and the SO<sub>x</sub> releasing rate g(T) from the SO<sub>x</sub> absorbent 18, and Fig. 26B shows a relationship between the correction coefficient Kt with respect to the basic fuel injection time TP (stoichiometric air-fuel ratio when Kt = 1.0, rich when Kt > 1.0, and lean when Kt < 1.0), the NO<sub>x</sub> releasing rate f(Kt) from the NO<sub>x</sub> absorbent 19, and the SO<sub>x</sub> releasing rate g(Kt) from the SO<sub>x</sub> absorbent 18.

[0100] In the NO<sub>x</sub> absorbent 19, when the temperature of the NO<sub>x</sub> absorbent 19 is almost 150°C or more, when the NO<sub>2</sub> on the surface of the platinum Pt no longer exists, the reaction is immediately advanced to the direction of (NO<sub>3</sub><sup>-</sup> → NO<sub>2</sub>), and the NO<sub>x</sub> is immediately released from the absorbent. Accordingly, as shown in Fig. 26A, even if the temperature of the NO<sub>x</sub> absorbent 19 is considerably low, the NO<sub>x</sub> releasing rate f(T) becomes considerably high. Namely, this means that NO<sub>x</sub> is released from the NO<sub>x</sub> absorbent 19 at a considerably high speed. Note that, as shown in Fig. 26A, as the temperature T of the NO<sub>x</sub> absorbent 19 becomes higher, the NO<sub>x</sub> releasing rate f(T) becomes higher, and as shown

in Fig. 26B, as the value of the correction coefficient Kt becomes larger, that is, the degree of richness of the air-fuel ratio of the exhaust gas becomes higher, the NO<sub>x</sub> releasing rate f(Kt) becomes higher.

[0101] Contrary to this, the SO<sub>x</sub> absorbed in the SO<sub>x</sub> absorbent 18 is stable in comparison with the NO<sub>x</sub> absorbed in the NO<sub>x</sub> absorbent 19, and therefore is difficult to be decomposed, and the decomposition of this SO<sub>x</sub> is not sufficiently caused unless the temperature T of the SO<sub>x</sub> absorbent 18 exceeds the temperature To determined according to the type of the SO<sub>x</sub> absorbent 18. Accordingly, as shown in Fig. 26A, when the temperature T of the SO<sub>x</sub> absorbent 18 is lower than To, the SO<sub>x</sub> releasing rate g(T) is extremely low, that is, almost no SO<sub>x</sub> is released from the SO<sub>x</sub> absorbent 18, and if the temperature T of the SO<sub>x</sub> absorbent 18 exceeds To, the SO<sub>x</sub> releasing function from the SO<sub>x</sub> absorbent 18 is substantially started. Note that, also for SO<sub>x</sub>, when the temperature T of the SO<sub>x</sub> absorbent 18 exceeds To, as shown in Fig. 26A, as the temperature T of the SO<sub>x</sub> absorbent 18 becomes higher, the SO<sub>x</sub> releasing rate g(T) becomes higher, and as shown in Fig. 26B, as the value of the correction coefficient Kt becomes larger, the SO<sub>x</sub> releasing rate g(Kt) becomes higher.

[0102] Figure 27A shows the cumulative NO<sub>x</sub> release from the NO<sub>x</sub> absorbent 19 and the cumulative SO<sub>x</sub> release from the SO<sub>x</sub> absorbent 18 when the air-fuel ratio of the inflowing exhaust gas to the NO<sub>x</sub> absorbent 19 and the SO<sub>x</sub> absorbent 18 is made rich when the temperature T of the NO<sub>x</sub> absorbent 19 and the SO<sub>x</sub> absorbent 18 is lower than To (Fig. 26A); and a solid line of Fig. 27B shows the cumulative NO<sub>x</sub> release from the NO<sub>x</sub> absorbent 19 and the cumulative SO<sub>x</sub> release from the SO<sub>x</sub> absorbent 18 when the air-fuel ratio of the inflowing exhaust gas to the NO<sub>x</sub> absorbent 19 and the SO<sub>x</sub> absorbent 18 is made rich when the temperature T of the NO<sub>x</sub> absorbent 19 and the SO<sub>x</sub> absorbent 18 is higher than To (Fig. 26A).

[0103] When the temperature T of the SO<sub>x</sub> absorbent 18 is lower than To, as shown in Fig. 26A, almost no SO<sub>x</sub> is released, and accordingly, at this time, when the air-fuel ratio of the exhaust gas flowing into the NO<sub>x</sub> absorbent 19 and the SO<sub>x</sub> absorbent 18 is made rich, as shown in Fig. 27A, the NO<sub>x</sub> is quickly released from the NO<sub>x</sub> absorbent 19, but almost no SO<sub>x</sub> is released from the SO<sub>x</sub> absorbent 18.

[0104] On the other hand, when the temperature T of the SO<sub>x</sub> absorbent 18 becomes higher than To, as shown in Fig. 26A, the SO<sub>x</sub> releasing function is carried out, and therefore, at this time, if the air-fuel ratio of the exhaust gas flowing into the NO<sub>x</sub> absorbent 19 and the SO<sub>x</sub> absorbent 18 is made rich, as indicated by the solid line in Fig. 27B, both of the NO<sub>x</sub> and SO<sub>x</sub> are released. In this case, the NO<sub>x</sub> is released from the NO<sub>x</sub> absorbent 19 in a short time, but the decomposition rate of SO<sub>x</sub> in the SO<sub>x</sub> absorbent 18 is low, and therefore the SO<sub>x</sub> is released from the SO<sub>x</sub> absorbent 18 only slowly. Note that, also in this case, when the temperature T of

the  $\text{SO}_x$  absorbent 18 becomes high, as seen from Fig. 26A, the  $\text{SO}_x$  releasing rate  $g(T)$  becomes high, and therefore, as indicated by a broken line in Fig. 27B, the  $\text{SO}_x$  is released from the  $\text{SO}_x$  absorbent 18 relatively fast.

[0105] Also, the  $\text{NO}_x$  release indicated by the solid line in Fig. 27B shows the  $\text{NO}_x$  release from the  $\text{SO}_x$  absorbent 18 in which a transition metal such as copper Cu, iron Fe, manganese Mn, nickel Ni, or the like, sodium Na, or lithium Li or the like is carried on the carrier made of alumina, and in the  $\text{SO}_x$  absorbent 18 in which for example titania  $\text{TiO}_2$  is carried on a carrier made of alumina, as indicated by the broken line in Fig. 27B,  $\text{SO}_x$  is released from the  $\text{SO}_x$  absorbent 18 relatively fast. In this way the  $\text{SO}_x$  releasing speed from the  $\text{SO}_x$  absorbent 18 changes also according to the type of the  $\text{SO}_x$  absorbent 18, and changes also according to the temperature  $T$  of the  $\text{SO}_x$  absorbent 18.

[0106] As mentioned before, if the air-fuel ratio of the exhaust gas flowing into the the  $\text{SO}_x$  absorbent 18 and the  $\text{NO}_x$  absorbent 19 is made rich when the temperature  $T$  of the  $\text{SO}_x$  absorbent 17 is higher than  $T_0$ , the  $\text{SO}_x$  is released from the  $\text{SO}_x$  absorbent 18, and the  $\text{NO}_x$  is released from the  $\text{NO}_x$  absorbent 19. At this time, if the exhaust gas flowing out from the  $\text{SO}_x$  absorbent 18 is made to flow into the  $\text{NO}_x$  absorbent 19, as mentioned before, the  $\text{SO}_x$  released from the  $\text{SO}_x$  absorbent 18 is absorbed into the  $\text{NO}_x$  absorbent 19. Therefore, in this embodiment, so as to prevent the  $\text{SO}_x$  released from the  $\text{SO}_x$  absorbent 18 from absorption into the  $\text{NO}_x$  absorbent 19 in this way, when the  $\text{SO}_x$  absorbent 18 should release the  $\text{SO}_x$ , the exhaust gas flowing out of the  $\text{SO}_x$  absorbent 18 is guided into the bypass passage 24.

[0107] Namely, in this embodiment, when the lean air-fuel mixture is burned, the switch valve 27 is held at the bypass closed position indicated by the solid line in Fig. 23, and accordingly, at this time, the exhaust gas flowing out of the  $\text{SO}_x$  absorbent 18 flows into the  $\text{NO}_x$  absorbent 19. Accordingly, at this time, the  $\text{SO}_x$  in the exhaust gas is absorbed by the  $\text{SO}_x$  absorbent 18, and therefore only the  $\text{NO}_x$  is absorbed into the  $\text{NO}_x$  absorbent 19. Subsequently, when the  $\text{SO}_x$  from the  $\text{SO}_x$  absorbent 18 should be released, as shown in Fig. 28, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is switched from lean to rich, and simultaneously the switch valve 27 is switched to the bypass opening position indicated by the broken line in Fig. 23. When the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes rich, as shown in Fig. 28,  $\text{SO}_x$  is released from the  $\text{SO}_x$  absorbent 18, but at this time, the flowing out exhaust gas from the  $\text{SO}_x$  absorbent 18 does not flow into the  $\text{NO}_x$  absorbent 19, but flows into the bypass passage 24.

[0108] Subsequently, when the releasing action of the  $\text{SO}_x$  should be stopped, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is switched from rich to lean, and simultane-

ously the switch valve 27 is switched to the bypass closed position indicated by the solid line in Fig. 23. When the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes lean, as shown in Fig. 28, the releasing action of  $\text{SO}_x$  from the  $\text{SO}_x$  absorbent 18 is stopped.

[0109] In this way, in the embodiment shown in Fig. 28, when the  $\text{SO}_x$  is being released from the  $\text{SO}_x$  absorbent 18, the exhaust gas flowing out of the  $\text{SO}_x$  absorbent 18 flows into the bypass passage 24, and therefore it becomes possible to prevent the  $\text{SO}_x$  from absorption into the  $\text{NO}_x$  absorbent 19. Note that, at this time, the unburnt HC and CO and  $\text{NO}_x$  are discharged from the engine, but as mentioned before, the  $\text{SO}_x$  absorbent 18 has a three-way catalytic function, and therefore these unburnt HC and CO and  $\text{NO}_x$  are considerably removed at the  $\text{SO}_x$  absorbent 18, and accordingly, at this time, there is no risk of releasing of a large amount of unburnt HC and CO and  $\text{NO}_x$  into the atmosphere.

[0110] Figure 29 and Fig. 30 show respectively different embodiments in which when the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich so as to release the  $\text{SO}_x$  from the  $\text{SO}_x$  absorbent 18, the releasing action of the  $\text{NO}_x$  from the  $\text{NO}_x$  absorbent 19 is carried out together with the former.

[0111] The embodiment shown in Fig. 29 shows the  $\text{SO}_x$  and  $\text{NO}_x$  releasing control which can be applied to a case where the  $\text{SO}_x$  releasing speed from the  $\text{SO}_x$  absorbent 18 is considerably slower in comparison with the  $\text{NO}_x$  releasing speed from the  $\text{NO}_x$  absorbent 19. As indicated by the solid line in Fig. 27B, where the  $\text{SO}_x$  releasing speed is slower in comparison with the  $\text{NO}_x$  releasing speed, when the air-fuel ratio of the exhaust gas flowing into the the  $\text{SO}_x$  absorbent 18 and the  $\text{NO}_x$  absorbent 19 is switched from lean to rich, the  $\text{NO}_x$  is released from the  $\text{NO}_x$  absorbent 19 in a short time, and in addition during a time when the releasing action of  $\text{NO}_x$  is carried out, almost no  $\text{SO}_x$  is released from the  $\text{SO}_x$  absorbent 18. Accordingly, in this embodiment, during a predetermined period after when the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is switched from lean to rich ( $Kt = KK1$ ) (a period for which  $Kt = KK1$  is maintained in Fig. 29), the switch valve 27 is held at the bypass closed position, and then when this predetermined period has elapsed, the switch valve 27 is switched to the bypass opening position. For the predetermined period after this (period for which  $Kt = KK2$  is maintained), the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is maintained rich ( $Kt = KK2$ ), and when this predetermined period has elapsed, the switch valve 27 is switched to the bypass closed position.

[0112] In this way, in this embodiment, in an initial stage when the air-fuel ratio of the air-fuel mixture is switched from lean to rich, the switch valve 27 is held at the bypass closed position, and therefore the  $\text{NO}_x$  is rapidly released from the  $\text{NO}_x$  absorbent 19. At this time, the releasing of the  $\text{SO}_x$  is started also from the  $\text{SO}_x$



absorbent 18, but the release of  $\text{SO}_x$  is small, and accordingly, even if this  $\text{SO}_x$  is absorbed into the  $\text{NO}_x$  absorbent 19, the amount of absorption of  $\text{SO}_x$  is not so much increased. The most part of the  $\text{SO}_x$  is released from the  $\text{SO}_x$  absorbent 18 after the switch valve 27 is switched to the bypass closed position, and accordingly the most part of the  $\text{SO}_x$  is fed into the bypass passage 24.

[0113] The embodiment shown in Fig. 30 shows the  $\text{SO}_x$  and  $\text{NO}_x$  releasing control controlled so as to prevent the  $\text{SO}_x$  from absorption into the  $\text{NO}_x$  absorbent 19 as much as possible. In this embodiment, when the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich, the switch valve 27 is switched to the bypass closed position. At this time, the releasing of the  $\text{SO}_x$  is started from the  $\text{SO}_x$  absorbent 18, and this  $\text{SO}_x$  is all fed into the bypass passage 24. Subsequently, when the releasing action of the  $\text{SO}_x$  from the  $\text{SO}_x$  absorbent 18 is almost completed, the switch valve 27 is switched to the bypass closed position while maintaining the air-fuel ratio of the air-fuel mixture rich. When the switch valve 27 is switched to the bypass closed position, the  $\text{NO}_x$  is rapidly released from the  $\text{NO}_x$  absorbent 19, and when the releasing action of  $\text{NO}_x$  from the  $\text{NO}_x$  absorbent 19 is completed, the air-fuel ratio of the air-fuel mixture is switched from rich to lean.

[0114] In this embodiment, after the  $\text{SO}_x$  releasing action from the  $\text{SO}_x$  absorbent 18 is completely terminated, if the switch valve 27 is switched from the bypass opening position to the bypass closed position, it is possible to completely prevent the  $\text{SO}_x$  from absorption into the  $\text{NO}_x$  absorbent 19.

[0115] Note that, even in a case where the releasing speed of the  $\text{SO}_x$  from the  $\text{SO}_x$  absorbent 18 is slow as indicated by the solid line in Fig. 27B, when the temperature of the  $\text{SO}_x$  absorbent 18 becomes high, as mentioned before, the  $\text{SO}_x$  releasing speed becomes faster. In this way, when the  $\text{SO}_x$  and  $\text{NO}_x$  releasing action as shown in Fig. 29 is carried out when the  $\text{SO}_x$  releasing speed becomes faster, immediately after the air-fuel ratio of the air-fuel mixture is switched from lean to rich, a large amount of the  $\text{SO}_x$  is released also from the  $\text{SO}_x$  absorbent 18, and thus a large amount of the  $\text{SO}_x$  becomes absorbed into the  $\text{NO}_x$  absorbent 19. Therefore, in another embodiment according to the present invention, when the temperature of the  $\text{SO}_x$  absorbent 18 is relatively low and the releasing speed of  $\text{SO}_x$  is slow, the releasing control of the  $\text{SO}_x$  and  $\text{NO}_x$  shown in Fig. 29 is carried out, and when the temperature of the  $\text{SO}_x$  absorbent 18 becomes high and the releasing speed of  $\text{SO}_x$  becomes faster, the releasing control of the  $\text{SO}_x$  and  $\text{NO}_x$  shown in Fig. 30 is carried out.

[0116] Figure 31 shows the releasing control timing of the  $\text{NO}_x$  and  $\text{SO}_x$ . Note that, this Fig. 31 shows a case using the embodiment shown in Fig. 29 as the  $\text{SO}_x$  releasing control. Also, in Fig. 31, P indicates the  $\text{NO}_x$  releasing control, and Q indicates the  $\text{NO}_x$  and  $\text{SO}_x$  releasing control.

[0117] In the embodiment shown in Fig. 31, the releasing processing of the  $\text{NO}_x$  and  $\text{SO}_x$  is carried out based on the  $\text{NO}_x$  amount  $W_n$  and the  $\text{SO}_x$  amount  $W_s$ . In this case, as the amount  $W_n$  of  $\text{NO}_x$  absorbed in the  $\text{NO}_x$  absorbent 19 and the amount  $W_s$  of  $\text{SO}_x$  absorbed in the  $\text{SO}_x$  absorbent 18, an estimated absorption amount estimated from the operation state of the engine is used. This  $\text{NO}_x$  amount  $W_n$  and  $\text{SO}_x$  amount  $W_s$  will be mentioned later.

[0118] As shown in Fig. 31, when the  $\text{NO}_x$  amount  $W_n$  exceeds the maximum allowable value  $W_{no}$ , the air-fuel ratio of the air-fuel mixture is made rich ( $K_t = K_{K1}$ ), and the releasing action of  $\text{NO}_x$  from the  $\text{NO}_x$  absorbent 19 is started. When the releasing action of  $\text{NO}_x$  is started, the  $\text{NO}_x$  amount  $W_n$  is rapidly reduced, and when the  $\text{NO}_x$  amount  $W_n$  reaches the lower limit value MIN, the air-fuel ratio of the air-fuel mixture is switched from rich to lean, and the releasing action of  $\text{NO}_x$  is stopped. Contrary to this, when the  $\text{SO}_x$  amount  $W_s$  exceeds the maximum allowable value  $W_{so}$ , the air-fuel ratio of the air-fuel mixture is made rich ( $K_t = K_{K1}$ ) for a predetermined period, and the releasing action of  $\text{NO}_x$  from the  $\text{NO}_x$  absorbent 19 is started. At this time, also the releasing action of  $\text{SO}_x$  from the  $\text{SO}_x$  absorbent 18 is started. Subsequently, when the  $\text{NO}_x$  amount  $W_n$  reaches the lower limit value MIN, the switch valve 27 is switched to the bypass opening position. Subsequently, when the  $\text{SO}_x$  amount  $W_s$  reaches the lower limit value MIN, the air-fuel ratio of the air-fuel mixture is switched from rich to lean, and the releasing action of  $\text{SO}_x$  is stopped.

[0119] Note that, as seen from Fig. 31, the period of making the air-fuel ratio of the air-fuel mixture rich so as to release the  $\text{NO}_x$  from the  $\text{NO}_x$  absorbent 19 is considerably short, and the air-fuel ratio of the air-fuel mixture is made rich with a proportion of one time per several minutes. On the other hand, as mentioned before, the amount of  $\text{SO}_x$  contained in the exhaust gas is considerably smaller than the amount of  $\text{NO}_x$ , and therefore a considerably long time is taken until the  $\text{SO}_x$  absorbent 18 is saturated by the  $\text{SO}_x$ . Accordingly, the period of making the air-fuel ratio of the air-fuel mixture rich so as to release the  $\text{SO}_x$  from the  $\text{SO}_x$  absorbent 18 is considerably short, and the air-fuel ratio of the air-fuel mixture is made rich with a proportion of for example one time per several hours.

[0120] Figures 32A to 32D show the flag switch valve control routine for executing the  $\text{NO}_x$  and  $\text{SO}_x$  releasing control shown in Fig. 28, which routine is executed by the interruption at every predetermined time interval.

[0121] Referring to Figs. 32A to 32D, first of all, at step 600 to step 608, the amount  $W_n$  of  $\text{NO}_x$  absorbed in the  $\text{NO}_x$  absorbent 19 and the amount  $W_s$  of  $\text{SO}_x$  absorbed in the  $\text{SO}_x$  absorbent 18 are calculated. Namely, first of all, at step 600, it is determined whether or not the correction coefficient  $K_t$  with respect to the basic fuel injection time TP is smaller than 1.0. When  $K_t < 1.0$ , that is, when the lean air-fuel mixture is fed into the combustion chamber 3, the processing routine goes to step 601, at

which the  $\text{NO}_x$  amount  $W_n$  is calculated based on the following equation, and then the processing routine goes to step 602, at which the  $\text{SO}_x$  amount  $W_s$  is calculated based on the following equation.

$$W_n = W_n + K_1 \cdot N \cdot PM$$

$$W_s = W_s + K_2 \cdot N \cdot PM$$

[0122] Here,  $N$  indicates the engine rotational speed;  $PM$  indicates the absolute pressure in the surge tank 10; and  $K_1$  and  $K_2$  indicate constants ( $K_1 > K_2$ ). The amount of the  $\text{NO}_x$  and amount of  $\text{SO}_x$  discharged from the engine per unit time are in proportion to the engine rotational speed  $N$  and in proportion to the absolute pressure  $PM$  in the surge tank 10, and therefore the  $\text{NO}_x$  amount  $W_n$  and the  $\text{SO}_x$  amount  $W_s$  are represented as in the above equations. Accordingly, it is seen from these equations that so far as the combustion of the lean air-fuel mixture is continued, the  $\text{NO}_x$  amount  $W_n$  and the  $\text{SO}_x$  amount  $W_s$  are increased. When the  $\text{NO}_x$  amount  $W_n$  is calculated at step 601, and the  $\text{SO}_x$  amount  $W_s$  is calculated at step 602, the processing routine goes to step 609.

[0123] On the other hand, when it is determined at step 600 that  $K_t \geq 1.0$ , that is, when air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is the stoichiometric air-fuel ratio or rich, the processing routine goes to step 603, at which the  $\text{NO}_x$  amount  $W_n$  is calculated based on the following equation, and then the processing routine goes to step 604, at which the  $\text{SO}_x$  amount  $W_s$  is calculated based on the following equation:

$$W_n = W_n - W_n \cdot f(T) \cdot f(K_t)$$

$$W_s = W_s - W_s \cdot g(T) \cdot g(K_t)$$

[0124] Here,  $f(T)$  and  $g(T)$  indicate the  $\text{NO}_x$  releasing rate and the  $\text{SO}_x$  releasing rate shown in Fig. 26A, respectively, and  $f(K_t)$  and  $g(K_t)$  indicate the  $\text{NO}_x$  releasing rate and the  $\text{SO}_x$  releasing rate shown in Fig. 26B, respectively. As shown in Fig. 26A, the  $\text{NO}_x$  releasing rate  $f(T)$  and the  $\text{SO}_x$  releasing rate  $g(T)$  are functions of the exhaust gas temperature  $T$ , and accordingly these  $\text{NO}_x$  releasing rate  $f(T)$  and  $\text{SO}_x$  releasing rate  $g(T)$  are calculated from the exhaust gas temperature  $T$  detected by the temperature sensor 22. Note that, it is also possible to directly detect the exhaust gas temperature  $T$  by the temperature sensor 22 in this way, but it is also possible to estimate the same from the absolute pressure  $PM$  in the surge tank 10 and the engine rotational speed  $N$ . In this case, it is sufficient if the relationship among the exhaust gas temperature  $T$ , the absolute

pressure  $PM$ , and the engine rotational speed  $N$  is found in advance by experiments, this relationship is stored in advance in the ROM 32 in the form of the map as shown in Fig. 33, and the exhaust gas temperature  $T$  is calculated from this map.

[0125] Also, as shown in Fig. 26B, the  $\text{NO}_x$  releasing rate  $f(K_t)$  and  $\text{SO}_x$  releasing rate  $g(K_t)$  are functions of the correction coefficient  $K_t$ , and accordingly the  $\text{NO}_x$  releasing rate  $f(K_t)$  and  $\text{SO}_x$  releasing rate  $g(K_t)$  are calculated from the correction coefficient  $K_t$ . An actual  $\text{NO}_x$  releasing rate is expressed by the product of the  $f(T)$  and the  $f(K_t)$ , and therefore this means that the amount of  $\text{NO}_x$  released from the  $\text{NO}_x$  absorbent 19 per unit time is expressed by  $W_n \cdot f(T) \cdot f(K_t)$ , and accordingly the amount  $W_n$  of  $\text{NO}_x$  absorbed in the  $\text{NO}_x$  absorbent 19 becomes like the above-mentioned equation. Similarly, the  $\text{SO}_x$  releasing rate is expressed by the product of the  $g(T)$  and the  $g(K_t)$ , and therefore this means that the amount of  $\text{SO}_x$  released from the  $\text{SO}_x$  absorbent 18 per unit time is expressed by  $W_s \cdot g(T) \cdot g(K_t)$ , and accordingly the amount  $W_s$  of  $\text{SO}_x$  absorbed in the  $\text{SO}_x$  absorbent 18 becomes like the above-mentioned equation. Accordingly, it is seen that both of the  $\text{NO}_x$  amount  $W_n$  and the  $\text{SO}_x$  amount  $W_s$  are reduced when  $K_t \geq 1.0$ . Note that, the  $\text{NO}_x$  amount  $W_n$  and the  $\text{SO}_x$  amount  $W_s$  calculated at step 601 to step 604 is stored in the backup RAM 33a.

[0126] When the  $\text{NO}_x$  amount  $W_n$  is calculated at step 603 and the  $\text{SO}_x$  amount  $W_s$  is calculated at step 604, the processing routine goes to step 605, at which it is determined whether or not the  $\text{NO}_x$  amount  $W_n$  becomes negative. When  $W_n < 0$ , the processing routine goes to step 606, at which  $W_n$  is made zero, and then the processing routine goes to step 607. At step 607, it is determined whether or not the  $\text{SO}_x$  amount  $W_s$  becomes negative. When  $W_s < 0$ , the processing routine goes to step 608, at which  $W_s$  is made zero, and then the processing routine goes to step 609.

[0127] At step 609, it is determined whether or not the correction coefficient  $K$  determined according to the engine rotation state shown in Fig. 25 is smaller than 1.0. When  $K < 1.0$ , that is, when the target air-fuel ratio determined according to the operation state of the engine is lean, the processing routine goes to step 610, at which it is determined whether or not the  $\text{SO}_x$  processing has been set. When the  $\text{SO}_x$  processing flag has not been set, the routine jumps to step 613, at which it is determined whether or not the  $\text{SO}_x$  releasing flag has been set. When the  $\text{SO}_x$  releasing flag has not been set, the processing routine goes to step 614, at which it is determined whether or not the  $\text{NO}_x$  releasing flag has been set. When the  $\text{NO}_x$  releasing flag has not been set, the processing routine goes to step 615.

[0128] At step 615, it is determined whether or not the  $\text{SO}_x$  amount  $W_s$  has become larger than the maximum allowable value  $W_{so}$  (Fig. 31). When  $W_s \leq W_{so}$ , the processing routine goes to step 616, at which it is determined whether or not the  $\text{NO}_x$  amount  $W_n$  has be-

come larger than the maximum allowable value  $W_{no}$ . When  $W_n \leq W_{no}$ , the processing cycle is completed. At this time, the lean air-fuel mixture is fed into the combustion chamber 3, and the switch valve 27 is held at the bypass closed position.

[0129] On the other hand, when it is determined at step 616 that the  $W_n$  becomes larger than  $W_{no}$ , the processing routine goes to step 617, at which the  $NO_x$  releasing flag is set, and then the processing cycle is completed. In the next processing cycle, it is determined at step 614 that the  $NO_x$  releasing flag has been set, and therefore the processing routine goes to step 618, at which the correction coefficient  $K_t$  is made  $KK_1$ . The value of this  $KK_1$  is a value of about 1.1 to 1.2 with which the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes about 12.0 to 13.5. When  $K_t$  is made  $KK_1$ , the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich. Subsequently, at step 619, it is determined whether or not the  $NO_x$  amount  $W_n$  has become smaller than the lower limit value  $MIN$  (Fig. 31), and when  $W_n \geq MIN$ , the processing cycle is completed. Contrary to this, when  $W_n$  becomes smaller than  $MIN$ , the processing routine goes to step 620, at which the  $NO_x$  releasing flag is set. When the  $NO_x$  releasing flag is reset, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is switched from rich to lean. Accordingly, during a period from when  $W_n$  becomes larger than  $W_{no}$  to when  $W_n$  becomes smaller than  $MIN$ , the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich, and during this time, the  $NO_x$  is released from the  $NO_x$  absorbent 19.

[0130] On the other hand, when it is decided at step 615 that the  $SO_x$  amount  $W_s$  has become larger than the maximum allowable value  $W_{so}$ , the processing routine goes to step 621, at which it is determined whether or not the temperature  $T$  of exhaust gas flowing into the  $SO_x$  absorbent 18 is higher than the set value  $T_o$  (Fig. 26A). When  $T \leq T_o$ , the processing cycle is completed. Contrary to this, when  $T > T_o$ , the processing routine goes to step 622, at which the  $SO_x$  releasing flag is set and then the processing cycle is completed.

[0131] In the next processing cycle, it is decided at step 613 that the  $SO_x$  releasing flag has been set, and therefore the processing routine goes to step 623, at which the correction coefficient  $K_t$  is made  $KK_2$ . The value of this  $KK_2$  is the value of about 1.1 to 1.2 with which the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes about 12.0 to 13.5. It is also possible to make the value of this  $KK_2$  different from the value of  $KK_1$ , and make the same as the same value as the value of  $KK_1$ . When the correction coefficient  $K_t$  is made  $KK_2$ , the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich. Subsequently, at step 624, the switch valve 27 is switched to the bypass opening position, and thus the exhaust gas flowing out of the  $SO_x$  absorbent 18 is fed into the bypass passage 24.

[0132] Subsequently, at step 625, it is determined whether or not the  $SO_x$  amount  $W_s$  has become smaller than the lower limit value  $MIN$ , and when  $W_s \geq MIN$ , the processing cycle is completed. Contrary to this, when  $W_s$  becomes smaller than  $MIN$ , the processing routine goes to step 626, at which the switch valve 27 is switched to the bypass closed position, and then the processing routine goes to step 627, at which the  $SO_x$  releasing flag is reset. When the  $SO_x$  releasing flag is reset, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is switched from rich to lean. Accordingly, when  $W_s$  becomes larger than  $W_{so}$ , if  $T > T_o$ , from when the  $W_s$  becomes larger than  $W_{so}$  to when  $W_s$  becomes smaller than  $MIN$ , the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich and, at the same time, the switch valve 27 is held at the bypass opening position. Thus, during this term, the  $SO_x$  is released from the  $SO_x$  absorbent 18, and the released  $SO_x$  is fed into the bypass passage 24.

[0133] On the other hand, when it is determined at step 609 that  $K \geq 1.0$ , that is, when the target air-fuel ratio of the air-fuel mixture which should be fed into the combustion chamber 3 becomes the stoichiometric air-fuel ratio or rich, the processing routine goes to step 628, at which the  $NO_x$  releasing flag is reset, and then the processing routine goes to step 629, at which the  $SO_x$  releasing flag is reset. Subsequently, at step 630, the switch valve control shown in Fig. 32D is carried out. In this switch valve control, as shown in Fig. 32D, first of all, it is determined at step 631 whether or not the  $SO_x$  processing flag has been set. When the  $SO_x$  flag has not been set, the processing routine goes to step 632, at which it is determined whether or not the  $SO_x$  amount  $W_s$  is larger than the set up value  $W_k$  ( $MIN < W_k < W_{so}$ ). When  $W_s \leq W_k$ , the processing routine goes to step 634, at which the switch valve 27 is made the bypass closed position. When  $W_s > W_k$  even if the  $SO_x$  is released from the  $SO_x$  absorbent 18, since the  $SO_x$  release is small, the switch valve 27 is made the bypass closed position.

[0134] Contrary to this, when  $W_s > W_k$ , the processing routine goes to step 633, at which it is determined whether or not the temperature  $T$  of exhaust gas flowing into the  $SO_x$  absorbent 18 is higher than the set value  $T_o$  (Fig. 26A). When  $T \leq T_o$ , the processing routine goes to step 634. Namely, when  $T \leq T_o$ , almost no  $SO_x$  is released from the  $SO_x$  absorbent 18, and therefore the switch valve 27 is made the bypass closed position. Note that, the  $NO_x$  is released from the  $NO_x$  absorbent 19 when the switch valve 27 is held at the bypass closed position.

[0135] On the other hand, when it is decided at step 633 that  $T > T_o$ , the processing routine goes to step 635, at which the  $SO_x$  processing flag is set. When the  $SO_x$  processing flag is set, the processing routine goes from step 631 to step 633, at which the switch valve 27 is switched to the bypass opening position. Namely, when  $W_s > W_k$  and  $T > T_o$ , a certain amount of  $SO_x$  is released from the  $SO_x$  absorbent 18, and therefore the switch

valve 27 is made the bypass opening position so as to feed the released  $\text{SO}_x$  into the bypass passage 24. Subsequently, at step 637, it is determined whether or not the amount  $W_s$  of  $\text{SO}_x$  becomes smaller than the lower limit value MIN. When  $W_s$  becomes smaller than MIN, the processing routine goes to step 638, at which the  $\text{SO}_x$  processing flag is reset. When the  $\text{SO}_x$  processing flag is reset, in the next processing cycle, the processing routine goes from step 631 to step 632, since it is determined that  $W_s$  is equal to or smaller than  $W_k$  at this time, and therefore the processing routine goes to step 634, at which the switch valve 27 is switched to the bypass closed position.

[0136] On the other hand, where the  $\text{SO}_x$  flag has been set when the operation state is changed from the state where  $K \geq 1.0$  to the state where  $K < 1.0$ , the processing routine goes from step 610 to step 611, at which the  $\text{SO}_x$  processing flag is reset. Subsequently, at step 612, the switch valve 27 is switched to the bypass closed position.

[0137] Figure 34 shows the calculation routine of the fuel injection time TAU, which routine is repeatedly executed.

[0138] Referring to Fig. 34, first of all, at step 650, the correction coefficient K determined in accordance with the engine operation state shown in Fig. 25 is calculated. Subsequently, at step 651, the basic fuel injection time TP is calculated from the map shown in Fig. 2. Subsequently, at step 652, it is determined whether or not the  $\text{NO}_x$  releasing flag has been set, and when the  $\text{NO}_x$  releasing flag has not been set, the processing routine goes to step 653, at which it is determined whether or not the  $\text{SO}_x$  releasing flag has been set. When the  $\text{SO}_x$  releasing flag has not been set, the processing routine goes to step 654, at which the correction coefficient K is made  $K_t$ , and then at step 655, the fuel injection time TAU ( $= TP \cdot K_t$ ) is calculated by multiplying the basic fuel injection time TP by  $K_t$ . Accordingly, when the  $\text{NO}_x$  releasing flag and the  $\text{SO}_x$  releasing flag have not been set, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes the air-fuel ratio determined by the correction coefficient K.

[0139] Contrary to this, when the  $\text{NO}_x$  releasing flag is set, the processing routine jumps to step 655, and when the  $\text{SO}_x$  releasing flag is set, the processing routine goes to step 655. When the  $\text{NO}_x$  releasing flag is set, in the routine shown in Figs. 32A to 32D,  $K_t$  is made equal to  $KK1$  ( $KK1 > 1.0$ ), and therefore the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich, while when the  $\text{SO}_x$  releasing flag is set, in the routine shown in Figs. 32A to 32D,  $K_t$  is made equal to  $KK2$  ( $KK2 > 1.0$ ), and therefore the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich.

[0140] Figures 35A to 35D show the flag switch valve control routine for executing the  $\text{NO}_x$  and  $\text{SO}_x$  releasing control shown in Fig. 29, which routine is executed by interruption at every predetermined time interval. Note

that, in this embodiment, the flow chart part shown in Fig. 35A, Fig. 35B, and Fig. 35D is substantially the same as the flow chart part shown in Fig. 32A, Fig. 32B, and Fig. 32D, and the part which is basically different from them is only the flow chart part shown in Fig. 35C. [0141] Namely, referring to Figs. 35A to 35D, first of all, at step 700, it is determined whether or not the correction coefficient  $K_t$  with respect to the basic fuel injection time TP is smaller than 1.0. When  $K_t < 1.0$ , that is, when the lean air-fuel mixture is fed into the combustion chamber 3, the processing routine goes to step 701, at which the  $\text{NO}_x$  amount  $W_n$  ( $= W_n + K_1 \cdot N \cdot PM$ ) is calculated, and then the processing routine goes to step 702, at which the  $\text{SO}_x$  amount  $W_s$  ( $= W_s + K_2 \cdot N \cdot PM$ ) is calculated. Here, N indicates the engine rotational speed, P indicates the absolute pressure in the surge tank 10, and  $K_1$  and  $K_2$  indicate constants ( $K_1 > K_2$ ). Then, the processing routine goes to step 709.

[0142] On the other hand, when it is determined at step 700 that  $K_t \geq 1.0$ , that is, when the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is the stoichiometric air-fuel ratio or rich, the processing routine goes to step 703, at which the  $\text{NO}_x$  amount  $W_n$  ( $= W_n - W_n \cdot f(T) \cdot f(K_t)$ ) is calculated, and then the processing routine goes to step 704, at which the  $\text{SO}_x$  amount  $W_s$  ( $= W_s - W_s \cdot g(T) \cdot g(K_t)$ ) is calculated. Here,  $f(T)$  and  $g(T)$  indicate the  $\text{NO}_x$  releasing rate and  $\text{SO}_x$  releasing rate shown in Fig. 26A, respectively, and  $f(K_t)$  and  $g(K_t)$  indicate the  $\text{NO}_x$  releasing rate and  $\text{SO}_x$  releasing rate shown in Fig. 26B, respectively.

[0143] When the  $\text{NO}_x$  amount  $W_n$  is calculated at step 703, and the  $\text{SO}_x$  amount  $W_s$  is calculated at step 704, the processing routine goes to step 705, at which it is determined whether or not the  $\text{NO}_x$  amount  $W_n$  has become negative. When  $W_n < 0$ , the processing routine goes to step 706, at which  $W_n$  is made zero, and then, the processing routine goes to step 707. At step 707, it is determined whether or not the  $\text{SO}_x$  amount  $W_s$  becomes negative. When  $W_s < 0$ , the processing routine goes to step 708, at which  $W_s$  is made zero, and then the processing routine goes to step 709.

[0144] At step 709, it is determined whether or not the correction coefficient K determined according to the engine operation state shown in Fig. 25 is smaller than 1.0. When  $K < 1.0$ , that is, when the target air-fuel ratio determined according to the operation state of the engine is lean, the processing routine goes to step 710, at which it is determined whether or not the  $\text{SO}_x$  processing has been set. When the  $\text{SO}_x$  processing flag has not been set, the routine jumps to step 713, at which it is determined whether or not the  $\text{SO}_x$  and  $\text{NO}_x$  releasing flag has been set. When the  $\text{SO}_x$  and  $\text{NO}_x$  releasing flag has not been set, the processing routine goes to step 714, at which it is determined whether or not the  $\text{NO}_x$  releasing flag has been set. When the  $\text{NO}_x$  releasing flag has not been set, the processing routine goes to step 715.

[0145] At step 715, it is determined whether or not the  $\text{SO}_x$  amount  $W_s$  has become larger than the maximum

allowable value  $W_{so}$  (Fig. 31). When  $W_s \leq W_{so}$ , the processing routine goes to step 716, at which it is determined whether or not the  $NO_x$  amount  $W_n$  has become larger than the maximum allowable value  $W_{no}$ . When  $W_n \leq W_{no}$ , the processing cycle is completed. At this time, the lean air-fuel mixture is fed into the combustion chamber 3, and the switch valve 27 is held at the bypass closed position.

[0146] On the other hand, when it is determined at step 716 that the  $W_n$  becomes larger than  $W_{no}$ , the processing routine goes to step 717, at which the  $NO_x$  releasing flag is set, and then the processing cycle is completed. In the next processing cycle, it is determined at step 714 that the  $NO_x$  releasing flag has been set, and therefore the processing routine goes to step 718, at which the correction coefficient  $K_t$  is made  $KK_1$ . The value of this  $KK_1$  is a value of about 1.1 to 1.2 with which the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes about 12.0 to 13.5. When  $K_t$  is made  $KK_1$ , the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich. Subsequently, at step 719, it is determined whether or not the  $NO_x$  amount  $W_n$  has become smaller than the lower limit value  $MIN$  (Fig. 31), and when  $W_n \geq MIN$ , the processing cycle is completed. Contrary to this, when  $W_n$  becomes smaller than  $MIN$ , the processing routine goes to step 720, at which the  $NO_x$  releasing flag is set. When the  $NO_x$  releasing flag is reset, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is switched from rich to lean. Accordingly, during a period from when  $W_n$  becomes larger than  $W_{no}$  to when  $W_n$  becomes smaller than  $MIN$ , the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich, and during this time, the  $NO_x$  is released from the  $NO_x$  absorbent 19.

[0147] On the other hand, when it is decided at step 715 that the  $SO_x$  amount  $W_s$  has become larger than the maximum allowable value  $W_{so}$ , the processing routine goes to step 721, at which it is determined whether or not the temperature  $T$  of exhaust gas flowing into the  $SO_x$  absorbent 18 is higher than the set value  $T_o$  (Fig. 26A). When  $T \leq T_o$ , the processing cycle is completed. Contrary to this, when  $T > T_o$ , the processing routine goes to step 722, at which the  $SO_x$  and  $NO_x$  releasing flag is set and then the processing cycle is completed.

[0148] In the next processing cycle, it is decided at step 713 that the  $SO_x$  and  $NO_x$  releasing flag has been set, and therefore the processing routine goes to step 723, at which it is determined whether or not the  $NO_x$  amount  $W_n$  has become smaller than the lower limit value  $MIN$ . When  $W_n > MIN$ , the processing routine goes to step 724, at which the correction coefficient  $K_t$  is made  $KK_1$ , and then the processing cycle is completed. Accordingly, when  $W_s$  becomes larger than  $W_{so}$ , the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich ( $K_t = KK_1$ ) until when  $W_n$  becomes smaller than  $MIN$ , and the switch valve 27 is held at the bypass closed position. Accordingly, the  $NO_x$

will be released from the  $NO_x$  absorbent 19 during this time.

[0149] On the other hand, when it is decided at step 723 that  $W_n$  becomes smaller than  $MIN$ , the processing routine goes to step 725, at which the correction coefficient  $K_t$  is made  $KK_2$ . The value of this  $KK_2$  is a value of about 1.1 to 1.2 with which the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes about 12.0 to 13.5. It is also possible to make the value of this  $KK_2$  different from the value of  $KK_1$ , or make this the same value as the value of  $KK_1$ . When the correction coefficient  $K_t$  is made  $KK_2$ , the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich. Subsequently, at step 726, the switch valve 27 is switched to the bypass opening position. Thus, the exhaust gas flowing out of the  $SO_x$  absorbent 18 is fed into the bypass passage 24.

[0150] Subsequently, at step 727, it is determined whether or not the  $SO_x$  amount  $W_s$  becomes smaller than the lower limit value  $MIN$ , and when  $W_s \geq MIN$ , the processing cycle is completed. Contrary to this, when  $W_s$  becomes smaller than  $MIN$ , the processing routine goes to step 728, at which the switch valve 27 is switched to the bypass closed position, and then the processing routine goes to step 729, at which the  $SO_x$  and  $NO_x$  releasing flag is reset. When the  $SO_x$  and  $NO_x$  releasing flag is reset, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is switched from rich to lean. Accordingly, if  $T > T_o$  when  $W_s$  becomes larger than  $W_{so}$ , the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich ( $K = KK_2$ ) from when  $W_n$  becomes smaller than  $MIN$  to when  $W_s$  becomes smaller than  $MIN$  and, at the same time, the switch valve 27 is made the bypass opening position. Thus, during this time, the  $SO_x$  is released from the  $SO_x$  absorbent 18, and the released  $SO_x$  is fed into the bypass passage 24.

[0151] On the other hand, when it is determined at step 709 that  $K \geq 1.0$ , that is, when the target air-fuel ratio of the air-fuel mixture which should be fed into the combustion chamber 3 becomes the stoichiometric air-fuel ratio or rich, the processing routine goes to step 730, at which the  $NO_x$  releasing flag is reset, and then the processing routine goes to step 731, at which the  $SO_x$  and  $NO_x$  releasing flag is reset. Subsequently, at step 732, the switch valve control shown in Fig. 35D is carried out. In this switch valve control, as shown in Fig. 35D, first of all, at step 733, it is determined whether or not the  $SO_x$  processing flag has been set. When the  $SO_x$  processing flag has not been set, the processing routine goes to step 734, at which it is determined whether or not the  $SO_x$  amount  $W_s$  is larger than the set value  $W_k$  ( $MIN < W_k < W_{so}$ ). When  $W_s \leq W_k$ , the processing routine goes to step 736, at which the switch valve 27 is made the bypass closed position. When  $W_s > W_k$ , even if the  $SO_x$  is released from the  $SO_x$  absorbent 18, the amount of the released  $SO_x$  is small, and therefore the switch valve 27 is made the bypass closed position.

[0152] Contrary to this, when  $W_s > W_k$ , the processing routine goes to step 735, at which it is determined whether or not the temperature  $T$  of exhaust gas flowing into the  $SO_x$  absorbent 18 is higher than the set value  $T_o$  (Fig. 26A). When  $T \leq T_o$ , the processing routine goes to step 736. Namely, when  $T \leq T_o$ , almost no  $SO_x$  is released from the  $SO_x$  absorbent 18, and therefore the switch valve 27 is made the bypass closed position. Note that, the  $NO_x$  is released from the  $NO_x$  absorbent 19 when the switch valve 27 is held at the bypass closed position.

[0153] On the other hand, when it is decided at step 735 that  $T > T_o$ , the processing routine goes to step 737, at which the  $SO_x$  processing flag is set. When the  $SO_x$  processing flag is set, the processing routine goes from step 733 to step 738, at which the switch valve 27 is switched to the bypass opening position. Namely, when  $W_s > W_k$  and  $T > T_o$ , a certain amount of the  $SO_x$  is released from the  $SO_x$  absorbent 18, and therefore the switch valve 27 is made the bypass opening position so as to feed the released  $SO_x$  into the bypass passage 24. Subsequently, at step 739, it is determined whether or not the amount  $W_s$  of  $SO_x$  becomes smaller than the lower limit value  $MIN$ . When  $W_s$  becomes smaller than  $MIN$ , the processing routine goes to step 740, at which the  $SO_x$  processing flag is reset. When the  $SO_x$  processing flag is reset, in the next processing cycle, the processing routine goes from step 733 to step 734, since it is determined that  $W_s$  is equal to or smaller than  $W_k$  at this time, and therefore the processing routine goes to step 736, at which the switch valve 27 is switched to the bypass closed position.

[0154] On the other hand, where the  $SO_x$  flag has been set when the operation state is changed from the state where  $K \geq 1.0$  to the state where  $K < 1.0$ , the processing routine goes from step 710 to step 711, at which the  $SO_x$  processing flag is reset. Subsequently, at step 712, the switch valve 27 is switched to the bypass closed position.

[0155] Figure 36 shows the calculation routine of the fuel injection time  $TAU$ , which routine is substantially the same as the routine shown in Fig. 34. Note that, this routine is repeatedly executed.

[0156] Namely, referring to Fig. 36, first of all, at step 750, the correction coefficient  $K$  determined in accordance with the engine operation state shown in Fig. 25 is calculated. Subsequently, at step 751, the basic fuel injection time  $TP$  is calculated from the map shown in Fig. 2. Subsequently, at step 752, it is determined whether or not the  $NO_x$  releasing flag has been set, and when the  $NO_x$  releasing flag has not been set, the processing routine goes to step 753, at which it is determined whether or not the  $SO_x$  and  $NO_x$  releasing flag has been set. When the  $SO_x$  and  $NO_x$  releasing flag has not been set, the processing routine goes to step 754, at which the correction coefficient  $K$  is made  $K_t$ , and then at step 755, the fuel injection time  $TAU (= TP \cdot K_t)$  is calculated by multiplying the basic fuel injection time  $TP$  by  $K_t$ . Ac-

cordingly, when the  $NO_x$  releasing flag and the  $SO_x$  and  $NO_x$  releasing flag have not been set, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes the air-fuel ratio determined by the correction coefficient  $K$ .

[0157] Contrary to this, when the  $NO_x$  releasing flag is set, the processing routine jumps to step 755, and when the  $SO_x$  and  $NO_x$  releasing flag is set, the processing routine goes to step 755. When the  $NO_x$  releasing flag is set, in the routine shown in Figs. 35A to 35D,  $K_t$  is made equal to  $KK1$  ( $KK1 > 1.0$ ), and therefore the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich, while when the  $SO_x$  and  $NO_x$  releasing flag is set, in the routine shown in Figs. 35A to 35D,  $K_t$  is made equal to  $KK1$  ( $KK1 > 1.0$ ), and then  $K_t$  is made equal to  $KK2$  ( $KK2 > 1.0$ ), and therefore the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich.

[0158] Figures 37A to 37D show the flag switch valve control routine for executing the  $NO_x$  and  $SO_x$  releasing control shown in Fig. 30, which routine is executed by interruption at every predetermined time interval. Note that, in this embodiment, the flow chart part shown in Fig. 37A, Fig. 37B, and Fig. 37D is substantially the same as the flow chart part shown in Fig. 32A, Fig. 32B, and Fig. 32D, and the part which is basically different from them is only the flow chart part shown in Fig. 37C.

[0159] Namely, referring to Figs. 37A to 37D, first of all, at step 800, it is determined whether or not the correction coefficient  $K_t$  with respect to the basic fuel injection time  $TP$  is smaller than 1.0. When  $K_t < 1.0$ , that is, when the lean air-fuel mixture is fed into the combustion chamber 3, the processing routine goes to step 801, at which the  $NO_x$  amount  $W_n (= W_n + K_1 \cdot N \cdot PM)$  is calculated, and then the processing routine goes to step 802, at which the  $SO_x$  amount  $W_s (= W_s + K_2 \cdot N \cdot PM)$  is calculated. Here,  $N$  indicates the engine rotational speed,  $P$  indicates the absolute pressure in the surge tank 10, and  $K_1$  and  $K_2$  indicate constants ( $K_1 > K_2$ ). Then, the processing routine goes to step 809.

[0160] On the other hand, when it is determined at step 800 that  $K_t \geq 1.0$ , that is, when the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is the stoichiometric air-fuel ratio or rich, the processing routine goes to step 803, at which the  $NO_x$  amount  $W_n (= W_n - W_n \cdot f(T) \cdot f(K_t))$  is calculated, and then the processing routine goes to step 804, at which the  $SO_x$  amount  $W_s (= W_s - W_s \cdot g(T) \cdot g(K_t))$  is calculated. Here,  $f(T)$  and  $g(T)$  indicate the  $NO_x$  releasing rate and  $SO_x$  releasing rate shown in Fig. 26A, respectively, and  $f(K_t)$  and  $g(K_t)$  indicate the  $NO_x$  releasing rate and  $SO_x$  releasing rate shown in Fig. 26B, respectively.

[0161] When the  $NO_x$  amount  $W_n$  is calculated at step 803, and the  $SO_x$  amount  $W_s$  is calculated at step 804, the processing routine goes to step 805, at which it is determined whether or not the  $NO_x$  amount  $W_n$  has become negative. When  $W_n < 0$ , the processing routine goes to step 806, at which  $W_n$  is made zero, and then,

the processing routine goes to step 807. At step 807, it is determined whether or not the  $\text{SO}_x$  amount  $W_s$  becomes negative. When  $W_s < 0$ , the processing routine goes to step 808, at which  $W_s$  is made zero, and then the processing routine goes to step 809.

[0162] At step 809, it is determined whether or not the correction coefficient  $K$  determined according to the engine operation state shown in Fig. 25 is smaller than 1.0. When  $K < 1.0$ , that is, when the target air-fuel ratio determined according to the operation state of the engine is lean, the processing routine goes to step 810, at which it is determined whether or not the  $\text{SO}_x$  processing has been set. When the  $\text{SO}_x$  processing flag has not been set, the routine jumps to step 813, at which it is determined whether or not the  $\text{SO}_x$  and  $\text{NO}_x$  releasing flag has been set. When the  $\text{SO}_x$  and  $\text{NO}_x$  releasing flag has not been set, the processing routine goes to step 814, at which it is determined whether or not the  $\text{NO}_x$  releasing flag has been set. When the  $\text{NO}_x$  releasing flag has not been set, the processing routine goes to step 815.

[0163] At step 815, it is determined whether or not the  $\text{SO}_x$  amount  $W_s$  has become larger than the maximum allowable value  $W_{so}$  (Fig. 31). When  $W_s \leq W_{so}$ , the processing routine goes to step 816, at which it is determined whether or not the  $\text{NO}_x$  amount  $W_n$  has become larger than the maximum allowable value  $W_{no}$ . When  $W_n \leq W_{no}$ , the processing cycle is completed. At this time, the lean air-fuel mixture is fed into the combustion chamber 3, and the switch valve 27 is held at the bypass closed position.

[0164] On the other hand, when it is determined at step 816 that the  $W_n$  becomes larger than  $W_{no}$ , the processing routine goes to step 817, at which the  $\text{NO}_x$  releasing flag is set, and then the processing cycle is completed. In the next processing cycle, it is determined at step 814 that the  $\text{NO}_x$  releasing flag has been set, and therefore the processing routine goes to step 818, at which the correction coefficient  $K_t$  is made  $KK_1$ . The value of this  $KK_1$  is a value of about 1.1 to 1.2 with which the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes about 12.0 to 13.5. When  $K_t$  is made  $KK_1$ , the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich. Subsequently, at step 819, it is determined whether or not the  $\text{NO}_x$  amount  $W_n$  has become smaller than the lower limit value  $MIN$  (Fig. 31), and when  $W_n \geq MIN$ , the processing cycle is completed. Contrary to this, when  $W_n$  becomes smaller than  $MIN$ , the processing routine goes to step 820, at which the  $\text{NO}_x$  releasing flag is set. When the  $\text{NO}_x$  releasing flag is reset, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is switched from rich to lean. Accordingly, during a period from when  $W_n$  becomes larger than  $W_{no}$  to when  $W_n$  becomes smaller than  $MIN$ , the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich, and during this time, the  $\text{NO}_x$  is released from the  $\text{NO}_x$  absorbent 19.

[0165] On the other hand, when it is decided at step

815 that the  $\text{SO}_x$  amount  $W_s$  has become larger than the maximum allowable value  $W_{so}$ , the processing routine goes to step 821, at which it is determined whether or not the temperature  $T$  of exhaust gas flowing into the  $\text{SO}_x$  absorbent 18 is higher than the set value  $T_o$  (Fig. 26A). When  $T \leq T_o$ , the processing cycle is completed. Contrary to this, when  $T > T_o$ , the processing routine goes to step 822, at which the  $\text{SO}_x$  and  $\text{NO}_x$  releasing flag is set and then the processing cycle is completed.

[0166] In the next processing cycle, it is decided at step 813 that the  $\text{SO}_x$  and  $\text{NO}_x$  releasing flag has been set, and therefore the processing routine goes to step 823, at which it is determined whether or not the  $\text{SO}_x$  amount  $W_s$  has become smaller than the lower limit value  $MIN$ . When  $W_s > MIN$ , the processing routine goes to step 824, at which the correction coefficient  $K_t$  is made  $KK_2$ . The value of this  $KK_2$  is a value of about 1.1 to 1.2 with which the air-fuel ratio of the air-fuel mixture fed into the engine combustion chamber 3 becomes about 12.0 to 13.5. It is also possible to make the value of this  $KK_2$  different from the value of  $KK_1$ , or make this the same value as the value of  $KK_1$ . When the correction coefficient  $K_t$  is made  $KK_2$ , the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich. Subsequently, at step 825, the switch valve 27 is switched to the bypass opening position. Subsequently, the processing cycle is completed. Accordingly, if  $T > T_o$  when  $W_s$  becomes larger than  $W_{so}$ , the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich from when  $W_s$  becomes larger than  $W_{so}$  to when  $W_s$  becomes smaller than  $MIN$  and, at the same time, the switch valve 27 is held at the bypass closed position. Thus, during this term, the  $\text{SO}_x$  is released from the  $\text{SO}_x$  absorbent 18, and the released  $\text{SO}_x$  is fed into the bypass passage 24.

[0167] On the other hand, when it is determined at step 823 that  $W_s$  becomes smaller than  $MIN$ , the processing routine goes to step 826, at which the correction coefficient  $K_t$  is made  $KK_1$ , and then the processing routine goes to step 827, at which the switch valve 27 is switched to the bypass closed position. Subsequently, at step 828, it is determined whether or not the  $\text{NO}_x$  amount  $W_n$  becomes smaller than the lower limit value  $MIN$ , and when  $W_n \geq MIN$ , the processing cycle is completed. Contrary to this, when  $W_n$  becomes smaller than  $MIN$ , the processing routine goes to step 829, at which the  $\text{SO}_x$  and  $\text{NO}_x$  releasing flag is reset, and then the processing cycle is completed. Accordingly, when  $W_s$  becomes smaller than  $MIN$ , the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich ( $K_t = KK_1$ ) until when  $W_n$  becomes smaller than  $MIN$ , and the switch valve 27 is held at the bypass closed position. Accordingly, this means that  $\text{NO}_x$  is released from the  $\text{NO}_x$  absorbent 19 during this time.

[0168] On the other hand, when it is determined at step 809 that  $K \geq 1.0$ , that is, when the target air-fuel ratio of the air-fuel mixture which should be fed into the combustion chamber 3 becomes the stoichiometric air-



fuel ratio or rich, the processing routine goes to step 830, at which the NO<sub>x</sub> releasing flag is reset, and then the processing routine goes to step 831, at which the SO<sub>x</sub> and NO<sub>x</sub> releasing flag is reset. Subsequently, at step 832, the switch valve control shown in Fig. 37D is carried out. In this switch valve control, as shown in Fig. 37D, first of all, at step 833, it is determined whether or not the SO<sub>x</sub> processing flag has been set. When the SO<sub>x</sub> processing flag has not been set, the processing routine goes to step 834, at which it is determined whether or not the SO<sub>x</sub> amount Ws is larger than the set up value Wk (MIN < Wk < Wso). When Ws ≤ Wk, the processing routine goes to step 836, at which the switch valve 27 is made the bypass closed position. When Ws > Wk, even if the SO<sub>x</sub> is released from the SO<sub>x</sub> absorbent 18, the amount of the released SO<sub>x</sub> is small, and therefore the switch valve 27 is made the bypass closed position. [0169] Contrary to this, when Ws > Wk, the processing routine goes to step 835, at which it is determined whether or not the temperature T of exhaust gas flowing into the SO<sub>x</sub> absorbent 18 is higher than the set value To (Fig. 26A). When T ≤ To, the processing routine goes to step 836. Namely, when T ≤ To, almost no SO<sub>x</sub> is released from the SO<sub>x</sub> absorbent 18, and therefore switch valve 27 is made the bypass closed position. Note that, the NO<sub>x</sub> is released from the NO<sub>x</sub> absorbent 19 when the switch valve 27 is held at the bypass closed position. [0170] On the other hand, when it is decided at step 835 that T > To, the processing routine goes to step 837, at which the SO<sub>x</sub> processing flag is set. When the SO<sub>x</sub> processing flag is set, the processing routine goes from step 833 to step 838, at which the switch valve 27 is switched to the bypass opening position. Namely, when Ws > Wk and T > To, a certain amount of the SO<sub>x</sub> is released from the SO<sub>x</sub> absorbent 18, and therefore the switch valve 27 is made the bypass opening position so as to feed the released SO<sub>x</sub> into the bypass passage 24. Subsequently, at step 839, it is determined whether or not the amount Ws of SO<sub>x</sub> becomes smaller than the lower limit value MIN. When Ws becomes smaller than MIN, the processing routine goes to step 840, at which the SO<sub>x</sub> processing flag is reset. When the SO<sub>x</sub> processing flag is reset, in the next processing cycle, the processing routine goes from step 833 to step 834, since it is determined that Ws is equal to or smaller than Wk at this time, and therefore the processing routine goes to step 836, at which the switch valve 27 is switched to the bypass closed position.

[0171] On the other hand, where the SO<sub>x</sub> flag has been set when the operation state is changed from the state where K ≥ 1.0 to the state where K < 1.0, the processing routine goes from step 810 to step 811, at which the SO<sub>x</sub> processing flag is reset. Subsequently, at step 812, the switch valve 27 is switched to the bypass closed position.

[0172] Figure 38 shows the calculation routine of the fuel injection time TAU, which routine is exactly the same as the routine shown in Fig. 36.

[0173] Namely, referring to Fig. 38, first of all, at step 850, the correction coefficient K determined in accordance with the engine operation state shown in Fig. 25 is calculated. Subsequently, at step 851, the basic fuel injection time TP is calculated from the map shown in Fig. 2. Subsequently, at step 852, it is determined whether or not the NO<sub>x</sub> releasing flag has been set, and when the NO<sub>x</sub> releasing flag has not been set, the processing routine goes to step 853, at which it is determined whether or not the SO<sub>x</sub> and NO<sub>x</sub> releasing flag has been set. When the SO<sub>x</sub> and NO<sub>x</sub> releasing flag has not been set, the processing routine goes to step 854, at which the correction coefficient K is made Kt, and then at step 855, the fuel injection time TAU (= TP · Kt) is calculated by multiplying the basic fuel injection time TP by Kt. Accordingly, when the NO<sub>x</sub> releasing flag and the SO<sub>x</sub> and NO<sub>x</sub> releasing flag have not been set, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes the air-fuel ratio determined by the correction coefficient K.

[0174] Contrary to this, when the NO<sub>x</sub> releasing flag is set, the processing routine jumps to step 855, and when the SO<sub>x</sub> and NO<sub>x</sub> releasing flag is set, the processing routine goes to step 855. When the NO<sub>x</sub> releasing flag is set, in the routine shown in Figs. 37A to 37D, Kt is made equal to KK1 (KK1 > 1.0), and therefore the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich, while when the SO<sub>x</sub> and NO<sub>x</sub> releasing flag is set, in the routine shown in Figs. 37A to 37D, Kt is made equal to KK2 (KK2 > 1.0), and then Kt is made equal to KK1 (KK1 > 1.0), and therefore the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich.

[0175] Figures 39A to 39E show the flag switch valve control routine for performing the NO<sub>x</sub> and SO<sub>x</sub> releasing control shown in Fig. 29 when the exhaust gas temperature T is lower than the set up temperature Tt, while performing the NO<sub>x</sub> and SO<sub>x</sub> releasing control shown in Fig. 30 when the exhaust gas temperature T becomes higher than the set temperature Tt, which routine is executed by interruption at every predetermined time interval. Note that, in this embodiment, the flow chart part shown in Fig. 39A, Fig. 39B, and Fig. 39E is substantially the same as the flow chart part shown in Fig. 32A, Fig. 32B, and Fig. 32D, and the part which is basically different from them is only a flow chart part shown in Fig. 39C and Fig. 39D.

[0176] Namely, referring to Figs. 39A to 39E, first of all, at step 900, it is determined whether or not the correction coefficient Kt with respect to the basic fuel injection time TP is smaller than 1.0. When Kt < 1.0, that is, when the lean air-fuel mixture is fed into the combustion chamber 3, the processing routine goes to step 901, at which the NO<sub>x</sub> amount Wn (= Wn + K<sub>1</sub> · N · PM) is calculated, and then the processing routine goes to step 902, at which the SO<sub>x</sub> amount Ws (= Ws + K<sub>2</sub> · N · PM) is calculated. Here, N indicates the engine rotational speed, P indicates the absolute pressure in the surge

tank 10, and  $K_1$  and  $K_2$  indicate constants ( $K_1 > K_2$ ). Then, the processing routine goes to step 909.

[0177] On the other hand, when it is determined at step 900 that  $Kt \geq 1.0$ , that is, when the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is the stoichiometric air-fuel ratio or rich, the processing routine goes to step 903, at which the  $NO_x$  amount  $Wn$  ( $= Wn - Wn \cdot f(T) \cdot f(Kt)$ ) is calculated, and then the processing routine goes to step 904, at which the  $SO_x$  amount  $Ws$  ( $= Ws - Ws \cdot g(T) \cdot g(Kt)$ ) is calculated. Here,  $f(T)$  and  $g(T)$  indicate the  $NO_x$  releasing rate and  $SO_x$  releasing rate shown in Fig. 26A, respectively, and  $f(Kt)$  and  $g(Kt)$  indicate the  $NO_x$  releasing rate and  $SO_x$  releasing rate shown in Fig. 26B, respectively

[0178] When the  $NO_x$  amount  $Wn$  is calculated at step 903, and the  $SO_x$  amount  $Ws$  is calculated at step 904, the processing routine goes to step 905, at which it is determined whether or not the  $NO_x$  amount  $Wn$  has become negative. When  $Wn < 0$ , the processing routine goes to step 906, at which  $Wn$  is made zero, and then, the processing routine goes to step 907. At step 907, it is determined whether or not the  $SO_x$  amount  $Ws$  becomes negative. When  $Ws < 0$ , the processing routine goes to step 908, at which  $Ws$  is made zero, and then the processing routine goes to step 909.

[0179] At step 909, it is determined whether or not the correction coefficient  $K$  determined according to the engine operation state shown in Fig. 25 is smaller than 1.0. When  $K < 1.0$ , that is, when the target air-fuel ratio determined according to the operation state of the engine is lean, the processing routine goes to step 910, at which it is determined whether or not the  $SO_x$  processing has been set. When the  $SO_x$  processing flag has not been set, the routine jumps to step 913, at which it is determined whether or not the  $SO_x$  and  $NO_x$  releasing flag has been set. When the  $SO_x$  and  $NO_x$  releasing flag has not been set, the processing routine goes to step 914, at which it is determined whether or not the  $NO_x$  releasing flag has been set. When the  $NO_x$  releasing flag has not been set, the processing routine goes to step 915.

[0180] At step 915, it is determined whether or not the  $SO_x$  amount  $Ws$  has become larger than the maximum allowable value  $Wso$  (Fig. 31). When  $Ws \leq Wso$ , the processing routine goes to step 916, at which it is determined whether or not the  $NO_x$  amount  $Wn$  has become larger than the maximum allowable value  $Wno$ . When  $Wn \leq Wno$ , the processing cycle is completed. At this time, the lean air-fuel mixture is fed into the combustion chamber 3, and the switch valve 27 is held at the bypass closed position.

[0181] On the other hand, when it is determined at step 916 that the  $Wn$  becomes larger than  $Wno$ , the processing routine goes to step 917, at which the  $NO_x$  releasing flag is set, and then the processing cycle is completed. In the next processing cycle, it is determined at step 914 that the  $NO_x$  releasing flag has been set, and therefore the processing routine goes to step 918, at which the correction coefficient  $Kt$  is made  $KK1$ . The

value of this  $KK1$  is a value of about 1.1 to 1.2 with which the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes about 12.0 to 13.5. When  $Kt$  is made  $KK1$ , the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich. Subsequently, at step 919, it is determined whether or not the  $NO_x$  amount  $Wn$  has become smaller than the lower limit value  $MIN$  (Fig. 31), and when  $Wn \geq MIN$ , the processing cycle is completed. Contrary to this, when  $Wn$  becomes smaller than  $MIN$ , the processing routine goes to step 920, at which the  $NO_x$  releasing flag is set. When the  $NO_x$  releasing flag is reset, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is switched from rich to lean. Accordingly, during a period from when  $Wn$  becomes larger than  $Wno$  to when  $Wn$  becomes smaller than  $MIN$ , the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich, and during this time, the  $NO_x$  is released from the  $NO_x$  absorbent 19.

[0182] On the other hand, when it is decided at step 915 that the  $SO_x$  amount  $Ws$  has become larger than the maximum allowable value  $Wso$ , the processing routine goes to step 921, at which it is determined whether or not the temperature  $T$  of exhaust gas flowing into the  $SO_x$  absorbent 18 is higher than the set value  $To$  (Fig. 26A). When  $T \leq To$ , the processing cycle is completed. Contrary to this, when  $T > To$ , the processing routine goes to step 922, at which the  $SO_x$  and  $NO_x$  releasing flag is set and then the processing cycle is completed.

[0183] In the next processing cycle, it is decided at step 913 that the  $SO_x$  and  $NO_x$  releasing flag has been set, and therefore the processing routine goes to step 923, at which it is determined whether or not the exhaust gas temperature  $T$  is higher than the set up temperature  $Tt$  ( $Tt > To$ ). When  $T \leq Tt$ , the processing routine goes to step 924, at which it is determined whether or not the  $NO_x$  amount  $Wn$  becomes smaller than the lower limit value  $MIN$ . When  $Wn > MIN$ , the processing routine goes to step 925, at which the correction coefficient  $Kt$  is made  $KK1$ , and then the processing cycle is completed. Accordingly, when  $To < T \leq Tt$ , if  $Ws$  becomes larger than  $Wso$ , the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich ( $Kt = KK1$ ) until  $Wn$  becomes smaller than  $MIN$ , and the switch valve 27 is held the bypass closed position. Accordingly, during this time, the  $NO_x$  will be released from the  $NO_x$  absorbent 19.

[0184] On the other hand, when it is decided at step 924 that  $Wn$  becomes smaller than  $MIN$ , the processing routine goes to step 926, at which the correction coefficient  $Kt$  is made  $KK2$ . The value of this  $KK2$  is a value of about 1.1 to 1.2 with which the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes about 12.0 to 13.5. It is also possible to make the value of this  $KK2$  different from the value of  $KK1$ , or make this the same value as the value of  $KK1$ . When the correction coefficient  $Kt$  is made  $KK2$ , the air-fuel ratio of the air-fuel mixture fed into the combustion

chamber 3 is made rich. Subsequently, at step 927, the switch valve 27 is switched to the bypass opening position. Thus, the exhaust gas flowing out of the  $\text{SO}_x$  absorbent 18 is fed into the bypass passage 24.

[0185] Subsequently, at step 928, it is determined whether or not the  $\text{SO}_x$  amount  $W_s$  becomes smaller than the lower limit value MIN, and when  $W_s \geq \text{MIN}$ , the processing cycle is completed. Contrary to this, when  $W_s$  becomes smaller than MIN, the processing routine goes to step 929, at which the switch valve 27 is switched to the bypass closed position, and then the processing routine goes to step 930, at which the  $\text{SO}_x$  and  $\text{NO}_x$  releasing flag is reset. When the  $\text{SO}_x$  and  $\text{NO}_x$  releasing flag is reset, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is switched from rich to lean. Accordingly, if  $T_t \geq T > T_o$  when  $W_s$  becomes larger than  $W_{no}$ , the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich ( $K = \text{KK2}$ ) from when  $W_n$  becomes smaller than MIN to when  $W_s$  becomes smaller than MIN and, at the same time, the switch valve 27 is made the bypass opening position. Thus, during this time, the  $\text{SO}_x$  is released from the  $\text{SO}_x$  absorbent 18, and the released  $\text{SO}_x$  is fed into the bypass passage 24.

[0186] On the other hand, when it is determined at step 923 that  $T > T_t$ , the processing routine goes to step 931, at which it is determined whether or not the  $\text{SO}_x$  amount  $W_s$  has become smaller than the lower limit value MIN. When  $W_s > \text{MIN}$ , the processing routine goes to step 932, at which the correction coefficient  $K_t$  is made  $\text{KK2}$ . When the correction coefficient  $K_t$  is made  $\text{KK2}$ , the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich. Subsequently, at step 933, the switch valve 27 is switched to the bypass opening position. Subsequently, the processing cycle is completed. Accordingly, if  $T > T_t$  when  $W_s$  becomes larger than  $W_{so}$ , the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich from when  $W_s$  becomes larger than  $W_{so}$  to when  $W_s$  becomes smaller than MIN and, at the same time, the switch valve 27 is held at the bypass closed position. Thus, during this term, the  $\text{SO}_x$  is released from the  $\text{SO}_x$  absorbent 18, and the released  $\text{SO}_x$  is fed into the bypass passage 24.

[0187] On the other hand, when it is determined at step 931 that  $W_s$  becomes smaller than MIN, the processing routine goes to step 934, at which the correction coefficient  $K_t$  is made  $\text{KK1}$ , and then the processing routine goes to step 935, at which the switch valve 27 is switched to the bypass closed position. Subsequently, at step 936, it is determined whether or not the  $\text{NO}_x$  amount  $W_n$  becomes smaller than the lower limit value MIN, and when  $W_n \geq \text{MIN}$ , the processing cycle is completed. Contrary to this, when  $W_n$  becomes smaller than MIN, the processing routine goes to step 937, at which the  $\text{SO}_x$  and  $\text{NO}_x$  releasing flag is reset, and then the processing cycle is completed. Accordingly, when  $W_s$  becomes smaller than MIN, the air-fuel ratio

of the air-fuel mixture fed into the combustion chamber 3 is made rich ( $K_t = \text{KK1}$ ) until when  $W_n$  becomes smaller than MIN, and the switch valve 27 is held at the bypass closed position. Accordingly, this means that  $\text{NO}_x$  is released from the  $\text{NO}_x$  absorbent 19 during this time.

[0188] On the other hand, when it is determined at step 909 that  $K \geq 1.0$ , that is, when the target air-fuel ratio of the air-fuel mixture which should be fed into the combustion chamber 3 becomes the stoichiometric air-fuel ratio or rich, the processing routine goes to step 938, at which the  $\text{NO}_x$  releasing flag is reset, and then the processing routine goes to step 939, at which the  $\text{SO}_x$  and  $\text{NO}_x$  releasing flag is reset. Subsequently, at step 940, the switch valve control shown in Fig. 39E is carried out. In this switch valve control, as shown in Fig. 39E, first of all, at step 941, it is determined whether or not the  $\text{SO}_x$  processing flag has been set. When the  $\text{SO}_x$  processing flag has not been set, the processing routine goes to step 942, at which it is determined whether or not the  $\text{SO}_x$  amount  $W_s$  is larger than the set value  $W_k$  ( $\text{MIN} < W_k < W_{so}$ ). When  $W_s \leq W_k$ , the processing routine goes to step 944, at which the switch valve 27 is made the bypass closed position. When  $W_s > W_k$ , even if the  $\text{SO}_x$  is released from the  $\text{SO}_x$  absorbent 18, the amount of the released  $\text{SO}_x$  is small, and therefore the switch valve 27 is made the bypass closed position.

[0189] Contrary to this, when  $W_s > W_k$ , the processing routine goes to step 943, at which it is determined whether or not the temperature  $T$  of exhaust gas flowing into the  $\text{SO}_x$  absorbent 18 is higher than the set value  $T_o$  (Fig. 26A). When  $T \leq T_o$ , the processing routine goes to step 944. Namely, when  $T \leq T_o$ , almost no  $\text{SO}_x$  is released from the  $\text{SO}_x$  absorbent 18, and therefore switch valve 27 is made the bypass closed position. Note that, the  $\text{NO}_x$  is released from the  $\text{NO}_x$  absorbent 19 when the switch valve 27 is held at the bypass closed position.

[0190] On the other hand, when it is decided at step 943 that  $T > T_o$ , the processing routine goes to step 945, at which the  $\text{SO}_x$  processing flag is set. When the  $\text{SO}_x$  processing flag is set, the processing routine goes from step 941 to step 946, at which the switch valve 27 is switched to the bypass opening position. Namely, when  $W_s > W_k$  and  $T > T_o$ , a certain amount of the  $\text{SO}_x$  is released from the  $\text{SO}_x$  absorbent 18, and therefore the switch valve 27 is made the bypass opening position so as to feed the released  $\text{SO}_x$  into the bypass passage 24. Subsequently, at step 947, it is determined whether or not the amount  $W_s$  of  $\text{SO}_x$  becomes smaller than the lower limit value MIN. When  $W_s$  becomes smaller than MIN, the processing routine goes to step 948, at which the  $\text{SO}_x$  processing flag is reset. When the  $\text{SO}_x$  processing flag is reset, in the next processing cycle, the processing routine goes from step 941 to step 942, since it is determined that  $W_s$  is equal to or smaller than  $W_k$  at this time, and therefore the processing routine goes to step 944, at which the switch valve 27 is switched to the bypass closed position.

[0191] On the other hand, where the  $\text{SO}_x$  flag has

been set when the operation state is changed from the state where  $K \geq 1.0$  to the state where  $K < 1.0$ , the processing routine goes from step 910 to step 911, at which the  $\text{SO}_x$  processing flag is reset. Subsequently, at step 912, the switch valve 27 is switched to the bypass closed position.

[0192] Figure 40 shows the calculation routine of the fuel injection time  $\text{TAU}$ , which routine is exactly the same as the routine shown in Fig. 36.

[0193] Namely, referring to Fig. 40, first of all, at step 950, the correction coefficient  $K$  determined in accordance with the engine operation state shown in Fig. 25 is calculated. Subsequently, at step 951, the basic fuel injection time  $\text{TP}$  is calculated from the map shown in Fig. 2. Subsequently, at step 952, it is determined whether or not the  $\text{NO}_x$  releasing flag has been set, and when the  $\text{NO}_x$  releasing flag has not been set, the processing routine goes to step 953, at which it is determined whether or not the  $\text{SO}_x$  and  $\text{NO}_x$  releasing flag has been set. When the  $\text{SO}_x$  and  $\text{NO}_x$  releasing flag has not been set, the processing routine goes to step 954, at which the correction coefficient  $K$  is made  $\text{Kt}$ , and then at step 955, the fuel injection time  $\text{TAU}$  ( $= \text{TP} \cdot \text{Kt}$ ) is calculated by multiplying the basic fuel injection time  $\text{TP}$  by  $\text{Kt}$ . Accordingly, when the  $\text{NO}_x$  releasing flag and the  $\text{SO}_x$  and  $\text{NO}_x$  releasing flag have not been set, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes the air-fuel ratio determined by the correction coefficient  $K$ .

[0194] Contrary to this, when the  $\text{NO}_x$  releasing flag is set, the processing routine jumps to step 955, and when the  $\text{SO}_x$  and  $\text{NO}_x$  releasing flag is set, the processing routine goes to step 955. When the  $\text{NO}_x$  releasing flag is set, in the routine shown in Figs. 39A to 39E,  $\text{Kt}$  is made equal to  $\text{KK1}$  ( $\text{KK1} > 1.0$ ), and therefore the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich, while when the  $\text{SO}_x$  and  $\text{NO}_x$  releasing flag is set, in the routine shown in Figs. 39A to 39E,  $\text{Kt}$  is made equal to  $\text{KK1}$  ( $\text{KK1} > 1.0$ ) or  $\text{Kt}$  is made equal to  $\text{KK2}$  ( $\text{KK2} > 1.0$ ), and therefore the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich.

#### Claims

1. A purification process for purifying exhaust gas of an internal combustion engine provided with:

an exhaust passage;  
an  $\text{NO}_x$  absorbent (19) which is arranged in said exhaust passage, absorbing the  $\text{NO}_x$  when the air-fuel ratio of an inflowing exhaust gas is lean and releasing the absorbed  $\text{NO}_x$  when an oxygen concentration in the inflowing exhaust gas is lowered;  
an  $\text{SO}_x$  absorbent (18) which is arranged in said exhaust passage on the upstream side of

said  $\text{NO}_x$  absorbent (19), absorbing the  $\text{SO}_x$  when the air-fuel ratio of the inflowing exhaust gas is lean and releasing the absorbed  $\text{SO}_x$  when the air-fuel ratio of the inflowing exhaust gas is made rich; and  
an air-fuel ratio control means which controls the air-fuel ratio of the exhaust gas,

characterized in that

the air-fuel ratio control means usually maintains the air-fuel ratio of the exhaust gas flowing into said  $\text{SO}_x$  absorbent (18) lean, and makes the air fuel ratio of the exhaust gas flowing into said  $\text{SO}_x$  absorbent (18) rich when the  $\text{SO}_x$  should be released from said  $\text{SO}_x$  absorbent (18).

2. A purification process according to claim 1, wherein all the exhaust gas discharged from the engine flows into the  $\text{SO}_x$  absorbent and the  $\text{NO}_x$  absorbent.
3. A purification process according to claim 1, wherein said air-fuel ratio control means controls the air-fuel ratio of the exhaust gas flowing into the  $\text{SO}_x$  absorbent by controlling the air-fuel ratio of the air-fuel mixture burned in the engine; the  $\text{SO}_x$  contained in the exhaust gas is absorbed into the  $\text{SO}_x$  absorbent when the air-fuel ratio of the exhaust gas flowing into the  $\text{SO}_x$  absorbent is maintained lean by maintaining the air-fuel ratio of the air-fuel mixture burned in the engine lean, while the  $\text{NO}_x$  contained in the exhaust gas is absorbed into the  $\text{NO}_x$  absorbent.
4. A purification process according to claim 3, wherein said air-fuel ratio control means releases the  $\text{SO}_x$  from the  $\text{SO}_x$  absorbent and, at the same time, makes the air-fuel ratio of the air-fuel mixture burned in the engine rich when the  $\text{NO}_x$  should be released from the  $\text{NO}_x$  absorbent.
5. A purification process according to claim 4, wherein when said air-fuel ratio control means should release the  $\text{SO}_x$  from the  $\text{SO}_x$  absorbent and, at the same time, release the  $\text{NO}_x$  from the  $\text{NO}_x$  absorbent, it first makes the air-fuel ratio of the exhaust gas flowing into the  $\text{SO}_x$  absorbent and the  $\text{NO}_x$  absorbent first degree of richness determined in advance, and then maintains the same at a rich state by a second degree of richness smaller than this first degree of richness.
6. A purification process according to claim 5, wherein said air-fuel ratio control means controls said first degree of richness and second degree of richness in accordance with a temperature representative of the temperature of the  $\text{SO}_x$  absorbent.

7. A purification process according to claim 6, wherein as temperature representing the temperature of the SOx absorbent the temperature of the exhaust gas flowing into the SOx absorbent is taken.
8. A purification process according to claim 6, wherein said air-fuel ratio control means makes said first degree of richness larger as the temperature representing the temperature of the SOx absorbent becomes higher.
9. A purification process according to claim 8, wherein said air-fuel ratio control means makes the time for which the air-fuel ratio of the exhaust gas is maintained at said first degree of richness shorter as the temperature representing the temperature of the SOx absorbent becomes higher.
10. A purification process according to claim 6, wherein said air-fuel ratio control means makes said second degree of richness larger as the temperature representing the temperature of the SOx absorbent becomes higher.
11. A purification process according to claim 10, wherein said air-fuel ratio control means makes the time for which the air-fuel ratio of the exhaust gas is maintained at said second degree of richness shorter as the temperature representing the temperature of the SOx absorbent becomes higher.
12. A purification process according to claim 4, wherein said air-fuel ratio control means makes the air-fuel ratio of the air-fuel mixture rich so as to release the NOx from the NOx absorbent with a time interval shorter than the time interval at which it makes the air-fuel ratio of the air-fuel mixture rich so as to release the SOx from the SOx absorbent and release the NOx from the NOx absorbent.
13. A purification process according to claim 12, wherein said air-fuel ratio control means first of all makes the air-fuel ratio of the exhaust gas flowing into the SOx absorbent and the NOx absorbent the predetermined degree of richness when the NOx should be released from the NOx absorbent, and then maintains the same at the stoichiometric air-fuel ratio.
14. A purification process according to claim 13, wherein said air-fuel ratio control means controls said degree of richness in accordance with a temperature representative of the temperature of the NOx absorbent.
15. A purification process according to claim 14, wherein as temperature representing the temperature of the NOx absorbent the temperature of the exhaust gas flowing into the NOx absorbent is taken.
16. A purification according to claim 14, wherein said air-fuel ratio control means makes said degree of richness larger as the temperature representing the temperature of the NOx absorbent becomes higher.
17. A purification process according to claim 16, wherein said air-fuel ratio control means makes the time for which the air-fuel ratio of the exhaust gas is maintained at said degree of richness shorter as the temperature representing the temperature of the NOx absorbent becomes higher.
18. A purification process according to claim 13, wherein said air-fuel ratio control means makes the time for which the air-fuel ratio of the exhaust gas is maintained at the stoichiometric air-fuel ratio shorter as the temperature representing the temperature of the SOx absorbent becomes higher.
19. A purification process according to claim 1, wherein the NOx absorbent is bypassed by a bypass passage which is branched from the exhaust passage positioned between the SOx absorbent and the NOx absorbent, the exhaust gas is selectively introduced to either of the NOx absorbent or the bypass passage, wherein a switch valve is held by a valve control means at a position at which the exhaust gas flows into the NOx absorbent when the NOx should be released from the NOx absorbent and is switched to a position at which the exhaust gas flowing into the bypass passage when the SOx should be released from the SOx absorbent, and said air-fuel ratio control means lowers the oxygen concentration in the exhaust gas flowing into the NOx absorbent when the NOx should be released from the NOx absorbent and makes the air-fuel ratio of the exhaust gas flowing into the SOx absorbent rich when the SOx should be released from the SOx absorbent.
20. A purification process according to claim 19, wherein said valve control means and said air-fuel ratio control means hold the switch valve at a position at which the exhaust gas flows into the NOx absorbent when the SOx should be released from the SOx absorbent and, at the same time, make the air-fuel ratio of the exhaust gas flowing into the SOx absorbent rich, and thereafter switches the switch valve to a position at which the exhaust gas flows into the bypass passage and, at the same time, continuously maintains the air-fuel ratio of the exhaust gas flowing into the SOx absorbent rich.
21. A purification process according to claim 20, wherein said valve control means and said air-fuel ratio control means hold the switch valve at a position at

- which the exhaust gas flows into the bypass passage when the SOx should be released from the SOx absorbent and, at the same time, make the air-fuel ratio of the exhaust gas flowing into the SOx absorbent rich, and thereafter switches the switch valve to the position at which the exhaust gas flows into the NOx absorbent and, at the same time, continuously maintains the air-fuel ratio of the exhaust gas flowing into the SOx absorbent rich.
22. A purification process according to claim 19, wherein said valve control means and said air-fuel ratio control means hold the switch valve at a position at which the exhaust gas flows into the NOx absorbent, if the temperature representing the temperature of the SOx absorbent is lower than the predetermined set up temperature when the SOx should be released from the SOx and, at the same time, make the air-fuel ratio of the exhaust gas flowing into the SOx absorbent rich, and thereafter switch the switch valve to a position at which the exhaust gas flows into the bypass passage and, at the same time, continuously maintain the air-fuel ratio of the exhaust gas flowing into the SOx absorbent rich; said valve control means and said air-fuel ratio control means switch the switch valve to a position at which the exhaust gas flows into the bypass passage, if the temperature representing the temperature of the SOx absorbent is higher than the predetermined set temperature when the SOx should be released from the SOx and, at the same time, make the air-fuel ratio of the exhaust gas flowing into the SOx absorbent rich, and thereafter hold the switch valve at a position at which the exhaust gas flows into the NOx absorbent and, at the same time, continuously maintain the air-fuel ratio of the exhaust gas flowing into the SOx absorbent rich.
23. A purification process according to claim 1, wherein the oxygen concentration in the exhaust gas flowing into the NOx absorbent is lowered by a NOx releasing control means exactly for a second set period determined in advance so as to release the NOx from the NOx absorbent when the period for which the air-fuel ratio of the exhaust gas flowing into the NOx absorbent is made lean and the NOx is absorbed into the NOx absorbent exceeds the predetermined first set period.
24. A purification process according to claim 23, wherein said NOx releasing control means provides a NOx amount estimation means which estimates the amount of NOx absorbed in the NOx absorbent, and said NOx releasing control means decides that said first set period has elapsed when the NOx amount estimated by said NOx amount estimation means exceeds a predetermined maximum value.
25. A purification process according to claim 24, wherein said NOx amount estimation means decides that the amount of NOx absorbed in the NOx absorbent exceeds said maximum value when the cumulative value of the engine rotational speed exceeds a predetermined set value.
26. A purification process according to claim 25, wherein said NOx amount estimation means estimates the amount of NOx absorbed into the NOx absorbent from the amount of NOx contained in the exhaust gas when the air-fuel ratio of the exhaust gas flowing into the NOx absorbent is lean, estimates the amount of NOx released from the NOx absorbent based on the degree of richness of said exhaust gas when the air-fuel ratio of the exhaust gas flowing into the NOx absorbent is rich and based on the temperature representing the temperature of the NOx absorbent, and estimates the amount of NOx continuously absorbed into the NOx absorbent from this estimated NOx release.
27. A purification process according to claim 26, wherein said NOx releasing control means decides that said second set period has elapsed when the NOx amount estimated by said NOx estimation means becomes smaller than a predetermined minimum value.
28. A purification process according to claim 1, wherein the air-fuel ratio of the exhaust gas flowing into the SOx absorbent is made rich by a SOx releasing control means exactly for a second set period determined in advance so as to release the SOx from the SOx absorbent when the period for which the air-fuel ratio of the exhaust gas flowing into the SOx absorbent is made lean and the SOx is absorbed into the SOx absorbent exceeds the predetermined first set period.
29. A purification process according to claim 28, wherein the amount of NOx absorbed in the SOx absorbent is estimated by a SOx amount estimation means provided by said SOx releasing control means, and said SOx releasing control means decides that said first set period has elapsed when the SOx amount estimated by said SOx amount estimation means exceeds a predetermined maximum value and decides that said second period has elapsed when the SOx amount estimated by said SOx amount estimation means becomes smaller than a predetermined maximum value.
30. A purification process according to claim 29, wherein said SOx amount estimation means estimates the amount of SOx absorbed into the SOx absorbent from the amount of SOx contained in the exhaust gas when the air-fuel ratio of the exhaust gas flow-

ing into the SOx absorbent is lean, estimates the amount of SOx released from the SOx absorbent based on the degree of richness of said exhaust gas when the air-fuel ratio of the exhaust gas flowing into the SOx absorbent is rich and based on the temperature representing the temperature of the SOx absorbent, and estimates the amount of SOx continuously absorbed into the SOx absorbent from this released SOx amount.

31. A purification process according to claim 1, wherein said air-fuel ratio control means controls the air-fuel ratio of the exhaust gas in the exhaust passage and makes the air-fuel ratio of the exhaust gas flowing into the SOx absorbent rich when the SOx should be released from the SOx absorbent.
32. A purification process according to claim 31, wherein said air-fuel ratio control means feeds a reduction agent into the exhaust passage when the SOx should be released from the SOx absorbent.
33. A purification process according to claim 32, wherein as reduction agent an agent is chosen composed of at least one member selected from gasoline, isooctane, hexane, heptane, butane, propane, light oil, and lamp oil.
34. An exhaust purification device for conducting the process according to claim 1, wherein the NOx absorbent contains at least one member selected from alkali metals consisting of potassium, sodium, lithium, cesium and alkali earths consisting of barium and calcium, and rare earths consisting of lanthanum, yttrium and platinum.
35. An exhaust purification device for conducting the process according to claim 1, wherein the SOx absorbent contains at least one member selected from copper, iron, manganese, nickel, sodium, tin, titanium, lithium and titania.
36. An exhaust purification device for conducting the process according to claim 1, wherein the SOx absorbent contains the platinum.
37. An exhaust purification device for conducting the process according to claim 2, wherein the SOx absorbent and the NOx absorbent are arranged in one casing.
38. An exhaust purification device for conducting the process according to claim 19, wherein provision is made of a bypass passage which is branched from the exhaust passage position between the SOx absorbent and the NOx absorbent; a switch valve is arranged at the branched portion of the bypass passage from the exhaust passage and a valve control

means is provided which forms the switching control of said switch valve.

## 5 Patentansprüche

1. Reinigungsverfahren zum Reinigen von Abgas einer Brennkraftmaschine, die mit folgendem versehen ist:

einem Abgaskanal;  
einem NOx Absorptionsmittel (19), das angeordnet ist in dem Abgaskanal, das die NOx absorbiert, wenn das Luft-Kraftstoffverhältnis eines einströmenden Abgases mager ist, und die absorbierten NOx freigibt, wenn eine Sauerstoffkonzentration in dem einströmenden Abgas gesenkt ist;  
einem SOx Absorptionsmittel (18), das angeordnet ist in dem Abgaskanal auf der stromaufwärtigen Seite des NOx Absorptionsmittels (19), das die SOx absorbiert, wenn das Luft-Kraftstoffverhältnis des einströmenden Abgases mager ist, und die absorbierten SOx freigibt, wenn das Luft-Kraftstoffverhältnis des einströmenden Abgases fett eingerichtet wird; und einer Luft-Kraftstoffverhältnisregeleinrichtung, die das Luft-Kraftstoffverhältnis des Abgases regelt,

dadurch gekennzeichnet, dass  
die Luft-Kraftstoffverhältnisregeleinrichtung gewöhnlich das Luft-Kraftstoffverhältnis des Abgases, das in das SOx Absorptionsmittel (18) einströmt, mager hält, und das Luft-Kraftstoffverhältnis des in das SOx Absorptionsmittel (18) einströmenden Abgases fett einrichtet, wenn die SOx freigegeben werden sollten aus dem SOx Absorptionsmittel (18).

2. Reinigungsverfahren nach Anspruch 1, wobei alle aus dem Motor abgegebenen Abgase in das SOx Absorptionsmittel und das NOx Absorptionsmittel einströmen.
3. Reinigungsverfahren nach Anspruch 1, wobei die Luft-Kraftstoffverhältnisregeleinrichtung das Luft-Kraftstoffverhältnis des in das SOx Absorptionsmittel einströmenden Abgases regelt durch Regeln des Luft-Kraftstoffverhältnisses des in dem Motor verbrannten Luft-Kraftstoffgemisches; wobei die in dem Abgas enthaltenen SOx absorbiert werden in dem SOx Absorptionsmittel, wenn das Luft-Kraftstoffverhältnis des in das SOx Absorptionsmittel einströmenden Abgases mager gehalten wird durch Magerhalten des Luft-Kraftstoffverhältnisses des in dem Motor verbrannten Luft-Kraftstoffgemisches, während die in dem Abgas enthaltenen NOx



in dem NOx Absorptionsmittel absorbiert werden.

4. Reinigungsverfahren nach Anspruch 3, wobei die Luft-Kraftstoffverhältnisregeleinrichtung die SOx aus dem SOx Absorptionsmittel freigibt und gleichzeitig das Luft-Kraftstoffverhältnis des in dem Motor verbrannten Luft-Kraftstoffgemisches fett einrichtet, wenn die NOx aus dem NOx Absorptionsmittel freigegeben werden sollten.
5. Reinigungsverfahren nach Anspruch 4, wobei, wenn die Luft-Kraftstoffverhältnisregeleinrichtung die SOx aus dem SOx Absorptionsmittel freigeben sollte und gleichzeitig die NOx aus dem NOx Absorptionsmittel freigeben sollte, sie zuerst das Luft-Kraftstoffverhältnis des in das SOx Absorptionsmittel und das NOx Absorptionsmittel einströmenden Abgases auf einen ersten Grad der Fettheit einrichtet, der vorher ermittelt ist, und dann denselben bei einem fetten Zustand hält durch einen zweiten Grad der Fettheit, der kleiner ist als dieser erste Grad der Fettheit.
6. Reinigungsverfahren nach Anspruch 5, wobei die Luft-Kraftstoffverhältnisregeleinrichtung den ersten Grad der Fettheit und den zweiten Grad der Fettheit regelt in Übereinstimmung mit einer Temperatur, die die Temperatur des SOx Absorptionsmittels repräsentiert.
7. Reinigungsverfahren nach Anspruch 6, wobei die Temperatur des Abgases, das in das SOx Absorptionsmittel einströmt, genommen wird als eine Temperatur, die die Temperatur des SOx Absorptionsmittels repräsentiert.
8. Reinigungsverfahren nach Anspruch 6, wobei die Luft-Kraftstoffverhältnisregeleinrichtung den ersten Grad der Fettheit größer einrichtet, wenn die Temperatur höher wird, die die Temperatur des SOx Absorptionsmittels repräsentiert.
9. Reinigungsverfahren nach Anspruch 8, wobei die Luft-Kraftstoffverhältnisregeleinrichtung die Zeit kürzer einrichtet, für die das Luft-Kraftstoffverhältnis des Abgases bei dem ersten Grad der Fettheit gehalten wird, wenn die Temperatur höher wird, die die Temperatur des SOx Absorptionsmittels repräsentiert.
10. Reinigungsverfahren nach Anspruch 6, wobei die Luft-Kraftstoffverhältnisregeleinrichtung den zweiten Grad der Fettheit größer einrichtet, wenn die Temperatur höher wird, die die Temperatur des SOx Absorptionsmittels repräsentiert.
11. Reinigungsverfahren nach Anspruch 10, wobei die Luft-Kraftstoffverhältnisregeleinrichtung die Zeit

kürzer einrichtet, für die das Luft-Kraftstoffverhältnis des Abgases bei dem zweiten Grad der Fettheit gehalten wird, wenn die Temperatur höher wird, die die Temperatur des SOx Absorptionsmittels repräsentiert.

12. Reinigungsverfahren nach Anspruch 4, wobei die Luft-Kraftstoffverhältnisregeleinrichtung das Luft-Kraftstoffverhältnis des Luft-Kraftstoffgemisches fett einrichtet, um die NOx aus dem NOx Absorptionsmittel freizugeben mit einem Zeitintervall, das kürzer ist als das Zeitintervall, bei dem das Luft-Kraftstoffverhältnis des Luft-Kraftstoffgemisches fett eingerichtet wird, um die SOx aus dem SOx Absorptionsmittel freizugeben und die NOx aus dem NOx Absorptionsmittel freizugeben.
13. Reinigungsverfahren nach Anspruch 12, wobei die Luft-Kraftstoffverhältnisregeleinrichtung zuerst das Luft-Kraftstoffverhältnis des Abgases, das in das SOx Absorptionsmittel und das NOx Absorptionsmittel einströmt, auf den vorgegebenen Grad der Fettheit einrichtet, wenn die NOx aus dem NOx Absorptionsmittel freigegeben werden sollten, und dann dasselbe bei dem stöchiometrischen Luft-Kraftstoffverhältnis hält.
14. Reinigungsverfahren nach Anspruch 13, wobei die Luft-Kraftstoffverhältnisregeleinrichtung den Grad der Fettheit regelt in Übereinstimmung mit einer Temperatur, die die Temperatur des NOx Absorptionsmittels repräsentiert.
15. Reinigungsverfahren nach Anspruch 14, wobei die Temperatur des in das NOx Absorptionsmittel einströmenden Abgases genommen wird als die Temperatur, die die Temperatur des NOx Absorptionsmittels repräsentiert.
16. Reinigungsverfahren nach Anspruch 14, wobei die Luft-Kraftstoffverhältnisregeleinrichtung den Grad der Fettheit größer einrichtet, wenn die Temperatur höher wird, die die Temperatur des NOx Absorptionsmittels repräsentiert.
17. Reinigungsverfahren nach Anspruch 16, wobei die Luft-Kraftstoffverhältnisregeleinrichtung die Zeit kürzer einrichtet, für die das Luft-Kraftstoffverhältnis des Abgases bei dem Grad der Fettheit gehalten wird, wenn die Temperatur höher wird, die die Temperatur des NOx Absorptionsmittels repräsentiert.
18. Reinigungsverfahren nach Anspruch 13, wobei die Luft-Kraftstoffverhältnisregeleinrichtung die Zeit kürzer einrichtet, für die das Luftkraftstoffverhältnis des Abgases bei dem stöchiometrischen Luftkraftstoffverhältnis gehalten wird, wenn die Temperatur höher wird, die die Temperatur des SOx Absorptionsmittels repräsentiert.

onsmittels repräsentiert.

19. Reinigungsverfahren nach Anspruch 1, wobei das NOx Absorptionsmittel mit einer Umgehungsleitung versehen ist durch einen Umgehungs kanal, der von dem Abgaskanal abzweigt an einer Position zwischen dem SOx Absorptionsmittel und dem NOx Absorptionsmittel, wobei das Abgas wahlweise eingeführt wird entweder in das NOx Absorptionsmittel oder den Umgehungs kanal, wobei ein Umschaltventil gehalten ist durch eine Ventilregeleinrichtung bei einer Position, bei der das Abgas in das NOx Absorptionsmittel einströmt, wenn die NOx freigegeben werden sollten aus dem NOx Absorptionsmittel, und zu einer Position geschaltet wird, bei der das Abgas in den Umgehungs kanal einströmt, wenn die SOx aus dem SOx Absorptionsmittel freigegeben werden sollten, und die Luft-Kraftstoffverhältnisregeleinrichtung die Sauerstoffkonzentration in dem Abgas senkt, das in das NOx Absorptionsmittel einströmt, wenn die NOx freigegeben werden sollten aus dem NOx Absorptionsmittel, und das Luft-Kraftstoffverhältnis des in das SOx Absorptionsmittel einströmenden Abgases fett einrichtet, wenn die SOx aus dem SOx Absorptionsmittel freigegeben werden sollten.
20. Reinigungsverfahren nach Anspruch 19, wobei die Ventilregeleinrichtung und die Luft-Kraftstoffverhältnisregeleinrichtung das Schaltventil bei einer Position halten, bei der das Abgas in das NOx Absorptionsmittel einströmt, wenn die SOx aus dem SOx Absorptionsmittel freigegeben werden sollten, und gleichzeitig das Luft-Kraftstoffverhältnis des in das SOx Absorptionmittel einströmenden Abgases fett einrichtet, und danach das Schaltventil zu einer Position schaltet, bei der das Abgas in den Umgehungs kanal einströmt, und gleichzeitig das Luftkraftstoffverhältnis des Abgases kontinuierlich fett hält, das in das SOx Absorptionsmittel einströmt.
21. Reinigungsverfahren nach Anspruch 20, wobei die Ventilregeleinrichtung und die Luft-Kraftstoffverhältnisregeleinrichtung das Schaltventil bei einer Position halten, bei der das Abgas in den Umgehungs kanal einströmt, wenn die SOx aus dem SOx Absorptionsmittel freigegeben werden sollten, und gleichzeitig das Luft-Kraftstoffverhältnis des in das SOx Absorptionsmittel einströmenden Abgases fett einrichtet, und danach das Schaltventil zu der Position schaltet, bei der das Abgas in das NOx Absorptionsmittel einströmt, und gleichzeitig das Luftkraftstoffverhältnis des in das SOx Absorptionsmittel einströmenden Abgases kontinuierlich fett hält.
22. Reinigungsverfahren nach Anspruch 19, wobei die Ventilregeleinrichtung und die Luft-Kraftstoffverhältnisregeleinrichtung das Schaltventil bei einer

Position halten, bei der das Abgas in das NOx Absorptionsmittel einströmt, wenn die Temperatur, die die Temperatur des SOx Absorptionsmittels repräsentiert, niedriger ist als die vorgegebene eingerichtete Temperatur, wenn die SOx freigegeben werden sollten aus dem SOx, und gleichzeitig das Luft-Kraftstoffverhältnis des in das SOx Absorptionsmittel einströmenden Abgases fett einrichtet und danach das Schaltventil zu einer Position schaltet, bei der das Abgas in den Umgehungs kanal einströmt und gleichzeitig das Luft-Kraftstoffverhältnis des in das SOx Absorptionsmittel einströmenden Abgases kontinuierlich fett hält; wobei die Ventilregeleinrichtung und die Luft-Kraftstoffverhältnisregeleinrichtung das Schaltventil zu einer Position schalten, bei der das Abgas in den Umgehungs kanal einströmt, wenn die Temperatur, die die Temperatur des SOx Absorptionsmittels repräsentiert, höher ist als die vorgegebene eingerichtete Temperatur, wenn die SOx freigegeben werden sollten aus dem SOx, und gleichzeitig das Luft-Kraftstoffverhältnis des in das SOx Absorptionsmittel einströmenden Abgases fett einrichtet und danach das Schaltventil bei einer Position hält, bei der das Abgas in das NOx Absorptionsmittel einströmt, und gleichzeitig kontinuierlich das Luft-Kraftstoffverhältnis des in das SOx Absorptionsmittel einströmenden Abgases fett hält.

23. Reinigungsverfahren nach Anspruch 1, wobei die Sauerstoffkonzentration in dem Abgas, das in das NOx Absorptionmittel einströmt, gesenkt wird durch eine NOx Freigaberegeleinrichtung genau für eine zweite eingerichtete Periode, die im voraus ermittelt ist, um die NOx aus dem NOx Absorptionsmittel freizugeben, wenn die Periode, für die das Luftkraftstoffverhältnis des in das NOx Absorptionsmittel einströmenden Abgases mager eingerichtet ist, und die NOx absorbiert werden in dem NOx Absorptionsmittel, die vorgegebene erste eingerichtete Periode überschreitet.
24. Reinigungsverfahren nach Anspruch 23, wobei die NOx Freigaberegeleinrichtung eine NOx Mengenschätzeinrichtung schafft, die die Menge der in dem NOx Absorptionsmittel absorbierten NOx schätzt, und die NOx Freigaberegeleinrichtung entscheidet, dass die erste eingerichtete Periode verstrichen ist, wenn die durch die NOx Mengenschätzeinrichtung geschätzte NOx Menge einen vorgegebenen Maximalwert überschreitet.
25. Reinigungsverfahren nach Anspruch 24, wobei die NOx Mengenschätzeinrichtung entscheidet, dass die Menge der in dem NOx Absorptionsmittel absorbierten NOx den Maximalwert überschreitet, wenn der kumulative Wert der Motordrehzahl einen vorgegebenen eingerichteten Wert überschreitet.

26. Reinigungsverfahren nach Anspruch 25, wobei die NOx Mengenschätzeinrichtung die Menge der in dem NOx Absorptionsmittel absorbierten NOx schätzt aus der Menge der in dem Abgas enthaltenen NOx, wenn das Luft-Kraftstoffverhältnis des in das NOx Absorptionsmittel einströmenden Abgases mager ist, die Menge der aus dem NOx Absorptionsmittel freigegebenen NOx schätzt auf der Grundlage des Grads der Fettheit des Abgases, wenn das Luft-Kraftstoffverhältnis des in das NOx Absorptionsmittel einströmenden Abgases fett ist, und auf der Grundlage der Temperatur, die die Temperatur des NOx Absorptionsmittels repräsentiert, und die Menge der NOx schätzt, die kontinuierlich absorbiert werden in dem NOx Absorptionsmittel, aus dieser geschätzten NOx Freigabe.
27. Reinigungsverfahren nach Anspruch 26, wobei die NOx Freigaberegeleinrichtung entscheidet, dass die zweite eingerichtete Periode verstrichen ist, wenn die durch die NOx Schätzeinrichtung geschätzte NOx Menge kleiner wird als ein vorgegebener Minimalwert.
28. Reinigungsverfahren nach Anspruch 1, wobei das Luft-Kraftstoffverhältnis des in das SOx Absorptionsmittel einströmenden Abgases fett eingerichtet wird durch eine SOx Freigaberegeleinrichtung genau für eine zweite eingerichtete Periode, die im voraus ermittelt wird, um die SOx freizugeben aus dem SOx Absorptionsmittel, wenn die Periode, für die das Luftkraftstoffverhältnis des in das SOx Absorptionsmittel einströmenden Abgases mager eingerichtet ist und die SOx absorbiert werden in dem SOx Absorptionsmittel, die vorgegebene erste eingerichtete Periode überschreitet.
29. Reinigungsverfahren nach Anspruch 28, wobei die Menge der in dem SOx Absorptionsmittel absorbierten NOx geschätzt wird durch eine SOx Mengenschätzeinrichtung, die durch die SOx Freigaberegeleinrichtung vorgesehen ist, und die SOx Freigaberegeleinrichtung entscheidet, dass die erste eingerichtete Periode verstrichen ist, wenn die durch die SOx Mengenschätzeinrichtung geschätzte SOx Menge einen vorgegebenen Maximalwert überschreitet, und entscheidet, dass die zweite Periode verstrichen ist, wenn die durch die SOx Mengenschätzeinrichtung geschätzte SOx Menge kleiner wird als ein vorgegebener Maximalwert.
30. Reinigungsverfahren nach Anspruch 29, wobei die SOx Mengenschätzeinrichtung die Menge der in dem SOx Absorptionsmittel absorbierten SOx schätzt aus der Menge der in dem Abgas enthaltenen SOx, wenn das Luft-Kraftstoffverhältnis des in das SOx Absorptionsmittel einströmenden Abgases mager ist, die Menge der aus dem SOx Absorptionsmittel freigegebenen SOx schätzt auf der Grundlage des Grads der Fettheit des Abgases, wenn das Luft-Kraftstoffverhältnis des Abgases, das in das SOx Absorptionsmittel einströmt, fett ist, und auf der Grundlage der Temperatur, die die Temperatur des SOx Absorptionsmittels repräsentiert, und die Menge der SOx, die kontinuierlich absorbiert wird in dem SOx Absorptionsmittel, aus dieser freigegebenen SOx Menge schätzt.
31. Reinigungsverfahren nach Anspruch 1, wobei die Luft-Kraftstoffverhältnisregeleinrichtung das Luft-Kraftstoffverhältnis des Abgases in dem Abgaskanal regelt und das Luftkraftstoffverhältnis des in das SOx Absorptionsmittel einströmenden Abgases fett einrichtet, wenn die SOx aus dem SOx Absorptionsmittel freigegeben werden sollten.
32. Reinigungsverfahren nach Anspruch 31, wobei die Luft-Kraftstoffverhältnisregeleinrichtung ein Reduktionsmittel in den Abgaskanal einspeist, wenn die SOx aus dem SOx Absorptionsmittel freigegeben werden sollten.
33. Reinigungsverfahren nach Anspruch 32, wobei als ein Reduktionsmittel ein Mittel gewählt wird, das zusammengesetzt ist zumindest aus einem Element, das ausgewählt ist aus Benzin, Isooktan, Hexan, Heptan, Butan, Propan, Leichtöl oder Lampenöl.
34. Abgasreinigungsvorrichtung zum Durchführen des Verfahrens nach Anspruch 1, wobei das NOx Absorptionsmittel zumindest ein Element enthält, das ausgewählt ist aus Alkalimetallen, die aus Kalium, Natrium, Lithium, Cäsium bestehen, und Alkalierden, die aus Barium oder Kalzium bestehen, und seltenen Erden, die aus Lanthan, Yttrium oder Platin bestehen.
35. Abgasreinigungsvorrichtung zum Durchführen des Verfahrens nach Anspruch 1, wobei das SOx Absorptionsmittel zumindest ein Element enthält, das ausgewählt ist aus Kupfer, Eisen, Mangan, Nickel, Natrium, Zinn, Titan, Lithium oder Titanerde.
36. Abgasreinigungsvorrichtung zum Durchführen des Verfahrens nach Anspruch 1, wobei das SOx Absorptionsmittel Platin enthält.
37. Abgasreinigungsvorrichtung zum Durchführen des Verfahrens nach Anspruch 2, wobei das SOx Absorptionsmittel und das NOx Absorptionsmittel in einer Ummantelung angeordnet sind.
38. Abgasreinigungsvorrichtung zum Durchführen des Verfahrens nach Anspruch 19, wobei ein Umgehungs kanal vorgesehen ist, der abzweigt von der Abgaskanalposition zwischen dem SOx Absorp-

onsmittel und dem NO<sub>x</sub> Absorptionsmittel; wobei ein Schaltventil angeordnet ist bei dem Abzweigungsabschnitt des Umgehungskanals von dem Abgaskanal, und eine Ventilregeleinrichtung vorgesehen ist, die die Schaltregelung des Schaltventils bildet.

#### Revendications

1. Procédé de purification destiné à purifier un gaz d'échappement d'un moteur à combustion interne muni de :
  - un passage d'échappement,
  - un adsorbant de NO<sub>x</sub> (19) qui est agencé dans ledit passage d'échappement, adsorbant le NO<sub>x</sub> lorsque le rapport air-carburant d'un gaz d'échappement entrant est pauvre et libérant le NO<sub>x</sub> adsorbé lorsqu'une concentration en oxygène dans le gaz d'échappement entrant est diminuée,
  - un adsorbant de SO<sub>x</sub> (18) qui est agencé dans ledit passage d'échappement du côté amont dudit adsorbant de NO<sub>x</sub> (19), adsorbant le SO<sub>x</sub> lorsque le rapport air-carburant du gaz d'échappement entrant est pauvre et libérant le SO<sub>x</sub> adsorbé lorsque le rapport air-carburant du gaz d'échappement entrant est rendu riche, et
  - un moyen de commande de rapport air-carburant qui commande le rapport air-carburant du gaz d'échappement,
  - caractérisé en ce que le moyen de commande de rapport air-carburant maintient habituellement pauvre le rapport air-carburant du gaz d'échappement circulant dans ledit adsorbant de SO<sub>x</sub> (18), et rend riche le rapport air-carburant du gaz d'échappement circulant dans ledit adsorbant de SO<sub>x</sub> (18) lorsque le SO<sub>x</sub> devrait être libéré dudit adsorbant de SO<sub>x</sub> (18).
2. Procédé de purification selon la revendication 1, dans lequel tout le gaz d'échappement rejeté du moteur circule dans l'adsorbant de SO<sub>x</sub> et l'adsorbant de NO<sub>x</sub>.
3. Procédé de purification selon la revendication 1, dans lequel ledit moyen de commande de rapport air-carburant commande le rapport air-carburant du gaz d'échappement circulant dans l'adsorbant de SO<sub>x</sub> en commandant le rapport air-carburant du mélange air-carburant brûlé dans le moteur, le SO<sub>x</sub> contenu dans le gaz d'échappement est adsorbé dans l'adsorbant de SO<sub>x</sub> lorsque le rapport air-carburant du gaz d'échappement circulant dans l'adsorbant de SO<sub>x</sub> est maintenu à l'état pauvre en maintenant le rapport air-carburant du mélange air-carburant brûlé dans le moteur à l'état pauvre, alors que le NO<sub>x</sub> contenu dans le gaz d'échappement est adsorbé dans l'adsorbant de NO<sub>x</sub>.
4. Procédé de purification selon la revendication 3, dans lequel ledit moyen de commande de rapport air-carburant libère le SO<sub>x</sub> de l'adsorbant de SO<sub>x</sub> et, en même temps rend riche le rapport air-carburant du mélange air-carburant brûlé dans le moteur lorsque le NO<sub>x</sub> devrait être libéré de l'adsorbant de NO<sub>x</sub>.
5. Procédé de purification selon la revendication 4, dans lequel, lorsque ledit moyen de commande de rapport air-carburant devrait libérer le SO<sub>x</sub> de l'adsorbant de SO<sub>x</sub> et, en même temps, libérer le NO<sub>x</sub> de l'adsorbant de NO<sub>x</sub>, il amène tout d'abord le rapport air-carburant du gaz d'échappement circulant dans l'adsorbant de SO<sub>x</sub> et l'adsorbant de NO<sub>x</sub> à un premier degré de richesse déterminé à l'avance, et ensuite maintient celui-ci dans un état riche par un second degré de richesse plus petit que ce premier degré de richesse.
6. Procédé de purification selon la revendication 5, dans lequel ledit moyen de commande de rapport air-carburant commande lesdits premier degré de richesse et second degré de richesse conformément à une température représentative de la température de l'adsorbant de SO<sub>x</sub>.
7. Procédé de purification selon la revendication 6, dans lequel en tant que température représentant la température de l'adsorbant de SO<sub>x</sub>, la température du gaz d'échappement circulant dans l'adsorbant de SO<sub>x</sub> est prélevée.
8. Procédé de purification selon la revendication 6, dans lequel ledit moyen de commande de rapport air-carburant rend ledit premier degré de richesse plus grand lorsque la température représentant la température de l'adsorbant de SO<sub>x</sub> devient plus élevée.
9. Procédé de purification selon la revendication 8, dans lequel ledit moyen de commande de rapport air-carburant rend le temps pendant lequel le rapport air-carburant du gaz d'échappement est maintenu audit premier degré de richesse, plus court lorsque la température représentant la température de l'adsorbant de SO<sub>x</sub> devient plus élevée.
10. Procédé de purification selon la revendication 6, dans lequel ledit moyen de commande de rapport air-carburant rend ledit second degré de richesse plus grand lorsque la température représentant la température de l'adsorbant de SO<sub>x</sub> devient plus élevée.

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11. Procédé de purification selon la revendication 10, dans lequel ledit moyen de commande de rapport air-carburant rend le temps pendant lequel le rapport air-carburant du gaz d'échappement est maintenu audit second degré de richesse, plus court lorsque la température représentant la température de l'adsorbant de  $\text{SO}_x$  devient plus élevée.
12. Procédé de purification selon la revendication 4, dans lequel ledit moyen de commande de rapport air-carburant rend riche le rapport air-carburant du mélange air-carburant de façon à libérer le  $\text{NO}_x$  de l'adsorbant de  $\text{NO}_x$  avec un intervalle de temps plus court que l'intervalle de temps pendant lequel il rend riche le rapport air-carburant du mélange air-carburant de façon à libérer le  $\text{SO}_x$  de l'adsorbant de  $\text{SO}_x$  et libérer le  $\text{NO}_x$  de l'adsorbant de  $\text{NO}_x$ .
13. Procédé de purification selon la revendication 12, dans lequel ledit moyen de commande de rapport air-carburant amène tout d'abord le rapport air-carburant du gaz d'échappement circulant dans l'adsorbant de  $\text{SO}_x$  et l'adsorbant de  $\text{NO}_x$  au degré de richesse prédéterminé lorsque le  $\text{NO}_x$  devrait être libéré de l'adsorbant de  $\text{NO}_x$  et maintient ensuite celui-ci au rapport air-carburant stoechiométrique.
14. Procédé de purification selon la revendication 13, dans lequel ledit moyen de commande de rapport air-carburant commande ledit degré de richesse conformément à une température représentative de la température de l'adsorbant de  $\text{NO}_x$ .
15. Procédé de purification selon la revendication 14, dans lequel en tant que température représentant la température de l'adsorbant de  $\text{NO}_x$ , la température du gaz d'échappement circulant dans l'adsorbant de  $\text{NO}_x$  est prélevée.
16. Procédé de purification selon la revendication 14, dans lequel ledit moyen de commande de rapport air-carburant rend ledit degré de richesse plus grand lorsque la température représentant la température de l'adsorbant de  $\text{NO}_x$  devient plus élevée.
17. Procédé de purification selon la revendication 16, dans lequel ledit moyen de commande de rapport air-carburant rend le temps pendant lequel le rapport air-carburant du gaz d'échappement est maintenu audit degré de richesse, plus court, lorsque la température représentant la température de l'adsorbant de  $\text{NO}_x$  devient plus élevée.
18. Procédé de purification selon la revendication 13, dans lequel ledit moyen de commande de rapport air-carburant rend le temps pendant lequel le rap-

port air-carburant du gaz d'échappement est maintenu au rapport air-carburant stoechiométrique, plus court lorsque la température représentant la température de l'adsorbant de  $\text{SO}_x$  devient plus élevée.

19. Procédé de purification selon la revendication 1, dans lequel l'adsorbant de  $\text{NO}_x$  est dérivé par un passage en dérivation qui est branché à partir du passage d'échappement positionné entre l'adsorbant de  $\text{SO}_x$  et l'adsorbant de  $\text{NO}_x$ , le gaz d'échappement est introduit sélectivement vers soit l'adsorbant de  $\text{NO}_x$  soit le passage de dérivation, dans lequel une vanne de commutation est maintenue par un moyen de commande de vanne à une position à laquelle le gaz d'échappement circule dans l'adsorbant de  $\text{NO}_x$  lorsque le  $\text{NO}_x$  devrait être libéré de l'adsorbant de  $\text{NO}_x$  et est basculée vers une position à laquelle le gaz d'échappement circulant dans le passage de dérivation lorsque le  $\text{SO}_x$  devrait être libéré de l'adsorbant de  $\text{SO}_x$ , et ledit moyen de commande de rapport air-carburant diminue la concentration en oxygène dans le gaz d'échappement circulant dans l'adsorbant de  $\text{NO}_x$  lorsque le  $\text{NO}_x$  devrait être libéré de l'adsorbant de  $\text{NO}_x$  et rend riche le rapport air-carburant du gaz d'échappement circulant dans l'adsorbant de  $\text{SO}_x$  lorsque le  $\text{SO}_x$  devrait être libéré de l'adsorbant de  $\text{SO}_x$ .
20. Procédé de purification selon la revendication 19, dans lequel ledit moyen de commande de vanne et ledit moyen de commande de rapport air-carburant maintiennent la vanne de commutation à une position à laquelle le gaz d'échappement circule dans l'adsorbant de  $\text{NO}_x$  lorsque le  $\text{SO}_x$  devrait être libéré de l'adsorbant de  $\text{SO}_x$  et, en même temps, rendent riche le rapport air-carburant du gaz d'échappement circulant dans l'adsorbant de  $\text{SO}_x$ , et ensuite basculent la vanne de commutation à une position à laquelle le gaz d'échappement circule dans le passage de dérivation et, en même temps, maintiennent de façon continue le rapport air-carburant du gaz d'échappement circulant dans l'adsorbant de  $\text{SO}_x$  à l'état riche.
21. Procédé de purification selon la revendication 20, dans lequel ledit moyen de commande de vanne et ledit moyen de commande de rapport air-carburant maintiennent la vanne de commutation à une position à laquelle le gaz d'échappement circule dans le passage de dérivation lorsque le  $\text{SO}_x$  devrait être libéré de l'adsorbant de  $\text{SO}_x$  et, en même temps, rendent riche le rapport air-carburant du gaz d'échappement circulant dans l'adsorbant de  $\text{SO}_x$ , et ensuite basculent la vanne de commutation à la position à laquelle le gaz d'échappement circule dans l'adsorbant de  $\text{NO}_x$  et, en même temps, main-

tiennent de façon continue le rapport air-carburant du gaz d'échappement circulant dans l'adsorbant de  $\text{SO}_x$  à l'état riche.

22. Procédé de purification selon la revendication 19, dans lequel ledit moyen de commande de vanne et ledit moyen de commande de rapport air-carburant maintiennent la vanne de commutation à une position à laquelle le gaz d'échappement circule dans l'adsorbant de  $\text{NO}_x$ , si la température représentant la température de l'adsorbant de  $\text{SO}_x$  est inférieure à la température établie prédéterminée lorsque le  $\text{SO}_x$  devrait être libéré de l'adsorbant de  $\text{SO}_x$  et, en même temps, rendent riche le rapport air-carburant du gaz d'échappement circulant dans l'adsorbant de  $\text{SO}_x$ , et basculent ensuite la vanne de commutation à une position à laquelle le gaz d'échappement circule dans le passage de dérivation et, en même temps, maintiennent de façon continue le rapport air-carburant du gaz d'échappement circulant dans l'adsorbant de  $\text{SO}_x$  à l'état riche, ledit moyen de commande de vanne et ledit moyen de commande de rapport air-carburant basculent la vanne de commutation à une position à laquelle le gaz d'échappement circule dans le passage de dérivation, si la température représentant la température de l'adsorbant de  $\text{SO}_x$  est plus élevée que la température établie prédéterminée lorsque le  $\text{SO}_x$  devrait être libéré de l'adsorbant de  $\text{SO}_x$  et, en même temps, rendent riche le rapport air-carburant du gaz d'échappement circulant dans l'adsorbant de  $\text{SO}_x$ , et ensuite maintiennent la vanne de commutation à une position à laquelle le gaz d'échappement circule dans l'adsorbant de  $\text{NO}_x$  et, en même temps, maintiennent de façon continue le rapport air-carburant du gaz d'échappement circulant dans l'adsorbant de  $\text{SO}_x$  à l'état riche.
23. Procédé de purification selon la revendication 1, dans lequel la concentration en oxygène dans le gaz d'échappement circulant dans l'adsorbant de  $\text{NO}_x$  est diminuée par un moyen de commande de libération de  $\text{NO}_x$  exactement pendant une seconde période établie déterminée à l'avance de façon à libérer le  $\text{NO}_x$  de l'adsorbant de  $\text{NO}_x$  lorsque la période pendant laquelle le rapport air-carburant du gaz d'échappement circulant dans l'adsorbant de  $\text{NO}_x$  est rendu pauvre, et le  $\text{NO}_x$  est adsorbé dans l'adsorbant de  $\text{NO}_x$ , dépasse la première période établie prédéterminée.
24. Procédé de purification selon la revendication 23, dans lequel ledit moyen de commande de libération de  $\text{NO}_x$  fournit un moyen d'estimation de quantité de  $\text{NO}_x$  qui estime la quantité de  $\text{NO}_x$  adsorbé dans l'adsorbant de  $\text{NO}_x$ , et ledit moyen de commande de libération de  $\text{NO}_x$  détermine que ladite première période établie s'est écoulée lorsque la quantité de

$\text{NO}_x$  estimée par ledit moyen d'estimation de quantité de  $\text{NO}_x$  dépasse une valeur maximum prédéterminée.

25. Procédé de purification selon la revendication 24, dans lequel ledit moyen d'estimation de quantité de  $\text{NO}_x$  détermine que la quantité de  $\text{NO}_x$  adsorbé dans l'adsorbant de  $\text{NO}_x$  dépasse ladite valeur maximum lorsque la valeur cumulative du régime de rotation du moteur dépasse une valeur établie prédéterminée.
26. Procédé de purification selon la revendication 25, dans lequel ledit moyen d'estimation de quantité de  $\text{NO}_x$  estime la quantité de  $\text{NO}_x$  adsorbé dans l'adsorbant de  $\text{NO}_x$  d'après la quantité de  $\text{NO}_x$  contenue dans les gaz d'échappement lorsque le rapport air-carburant du gaz d'échappement circulant dans l'adsorbant de  $\text{NO}_x$  est pauvre, estime la quantité de  $\text{NO}_x$  libéré de l'adsorbant de  $\text{NO}_x$  sur la base du degré de richesse dudit gaz d'échappement lorsque le rapport air-carburant du gaz d'échappement circulant dans l'adsorbant de  $\text{NO}_x$  est riche et sur la base de la température représentant la température de l'adsorbant de  $\text{NO}_x$ , et estime la quantité de  $\text{NO}_x$  adsorbé de façon continue dans l'adsorbant de  $\text{NO}_x$  d'après cette libération estimée de  $\text{NO}_x$ .
27. Procédé de purification selon la revendication 26, dans lequel ledit moyen de commande de libération de  $\text{NO}_x$  détermine que ladite période établie s'est écoulée lorsque la quantité de  $\text{NO}_x$  estimée par ledit moyen d'estimation de  $\text{NO}_x$  devient plus petite qu'une valeur minimum prédéterminée.
28. Procédé de purification selon la revendication 1, dans lequel le rapport air-carburant du gaz d'échappement circulant dans l'adsorbant de  $\text{SO}_x$  est rendu riche par un moyen de commande de libération de  $\text{SO}_x$  exactement pendant une seconde période établie déterminée à l'avance de façon à libérer le  $\text{SO}_x$  de l'adsorbant de  $\text{SO}_x$  lorsque la période pendant laquelle le rapport air-carburant du gaz d'échappement circulant dans l'adsorbant de  $\text{SO}_x$  est rendu pauvre et le  $\text{SO}_x$  est adsorbé dans l'adsorbant de  $\text{SO}_x$ , dépasse la première période établie prédéterminée.
29. Procédé de purification selon la revendication 28, dans lequel la quantité de  $\text{NO}_x$  adsorbé dans l'adsorbant de  $\text{SO}_x$  est estimée par un moyen d'estimation de quantité de  $\text{SO}_x$  fourni par ledit moyen de commande de libération de  $\text{SO}_x$ , et ledit moyen de commande de libération de  $\text{SO}_x$  détermine que ladite première période établie s'est écoulée lorsque la quantité de  $\text{SO}_x$  estimée par ledit moyen d'estimation de quantité de  $\text{SO}_x$  dépasse une valeur maximum prédéterminée, et détermine que ladite

seconde période s'est écoulée lorsque la quantité de  $\text{SO}_x$  estimée par ledit moyen d'estimation de quantité de  $\text{SO}_x$  devient plus petite qu'une valeur maximum prédéterminée.

30. Procédé de purification selon la revendication 29, dans lequel ledit moyen d'estimation de quantité de  $\text{SO}_x$  estime la quantité de  $\text{SO}_x$  absorbé dans l'adsorbant de  $\text{SO}_x$  d'après la quantité de  $\text{SO}_x$  contenue dans le gaz d'échappement lorsque le rapport air-carburant du gaz d'échappement circulant dans l'adsorbant de  $\text{SO}_x$  est pauvre, et estime la quantité de  $\text{SO}_x$  libéré de l'adsorbant de  $\text{SO}_x$  sur la base du degré de richesse dudit gaz d'échappement lorsque le rapport air-carburant du gaz d'échappement circulant dans l'adsorbant de  $\text{SO}_x$  est riche et sur la base de la température représentant la température de l'adsorbant de  $\text{SO}_x$ , et estime la quantité de  $\text{SO}_x$  absorbé de façon continue dans l'adsorbant de  $\text{SO}_x$  d'après cette quantité de  $\text{SO}_x$  libérée.
31. Procédé de purification selon la revendication 1, dans lequel ledit moyen de commande de rapport air-carburant commande le rapport air-carburant du gaz d'échappement dans le passage d'échappement et rend riche le rapport air-carburant du gaz d'échappement circulant dans l'adsorbant de  $\text{SO}_x$  lorsque le  $\text{SO}_x$  devrait être libéré de l'adsorbant de  $\text{SO}_x$ .
32. Procédé de purification selon la revendication 31, dans lequel ledit moyen de commande de rapport air-carburant fait passer un agent de réduction dans le passage d'échappement lorsque le  $\text{SO}_x$  devrait être libéré de l'adsorbant de  $\text{SO}_x$ .
33. Procédé de purification selon la revendication 32, dans lequel en tant qu'agent de réduction, un agent est choisi composé d'au moins un élément sélectionné à partir de l'essence, de l'isooctane, de l'hexane, de l'heptane, du butane, du propane, du pétrole léger et du pétrole lampant.
34. Dispositif de purification d'échappement destiné à exécuter le procédé selon la revendication 1, dans lequel l'adsorbant de  $\text{NO}_x$  contient au moins un élément sélectionné à partir des métaux alcalins constitués du potassium, du sodium, du lithium, du césium et des éléments alcalino-terreux constitués du baryum et du calcium, et des terres rares constituées du lanthane, de l'yttrium et du platine.
35. Dispositif de purification d'échappement destiné à exécuter le procédé selon la revendication 1, dans lequel l'adsorbant de  $\text{SO}_x$  contient au moins un élément sélectionné à partir du cuivre, du fer, du manganèse, du nickel, du sodium, de l'étain, du titane, du lithium et de l'oxyde de titane.
36. Dispositif de purification d'échappement destiné à exécuter le procédé selon la revendication 1, dans lequel l'adsorbant de  $\text{SO}_x$  contient le platine.
37. Dispositif de purification d'échappement destiné à exécuter le procédé selon la revendication 2, dans lequel l'adsorbant de  $\text{SO}_x$  et l'adsorbant de  $\text{NO}_x$  sont disposés dans un carter.
38. Dispositif de purification d'échappement destiné à exécuter le procédé selon la revendication 19, dans lequel il est prévu un passage de dérivation qui est branché à partir de la position de passage d'échappement entre l'adsorbant de  $\text{SO}_x$  et l'adsorbant de  $\text{NO}_x$ , une vanne de commutation est agencée au niveau de la partie dérivée du passage de dérivation depuis le passage d'échappement et un moyen de commande de vanne est prévu, lequel forme la commande de commutation de ladite vanne de commutation.



Fig.1

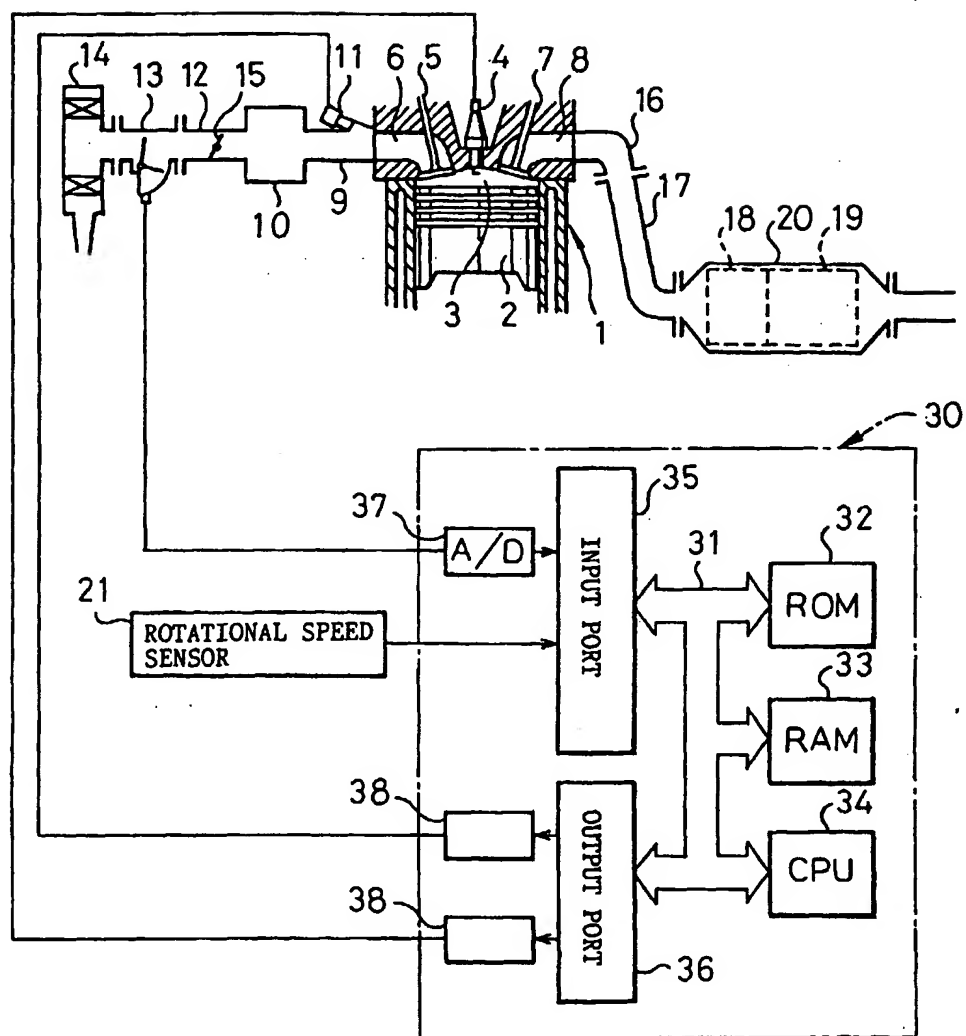


Fig. 2

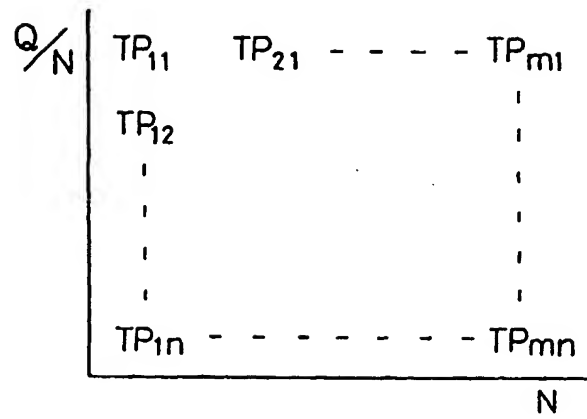


Fig. 3

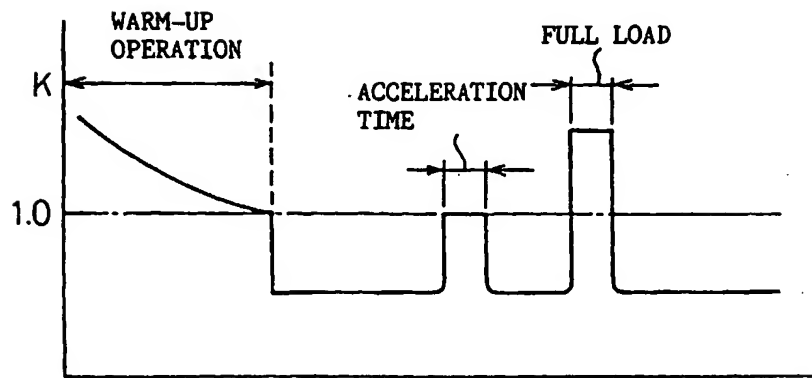


Fig.4

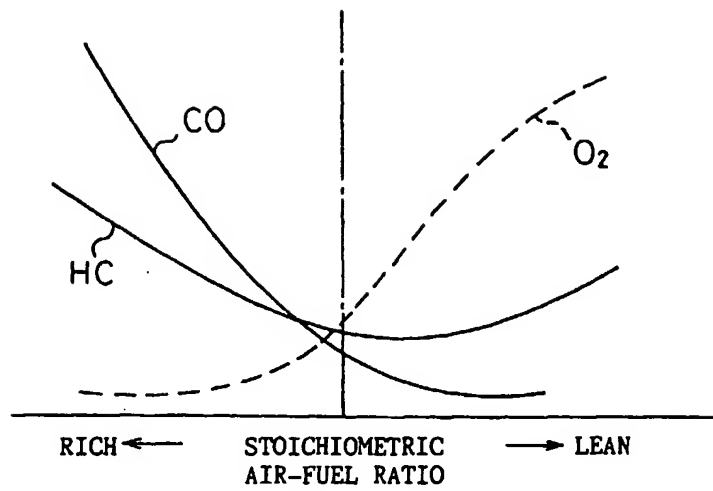


Fig. 5A

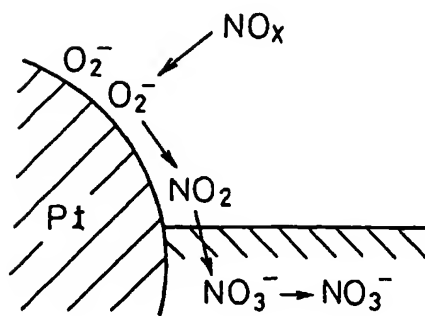


Fig.5B

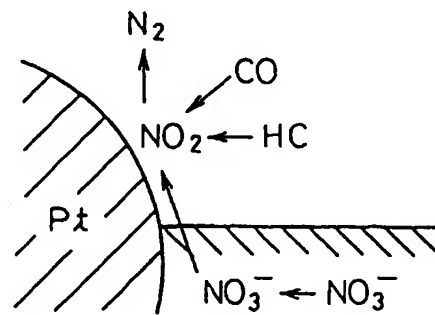


Fig.6

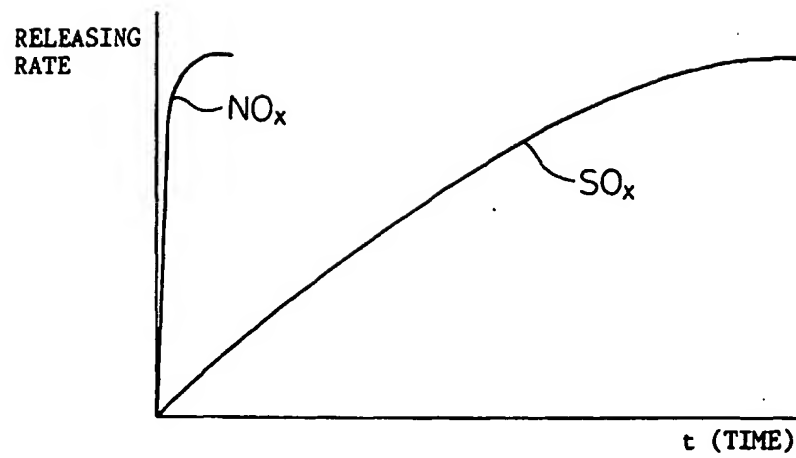


Fig.7

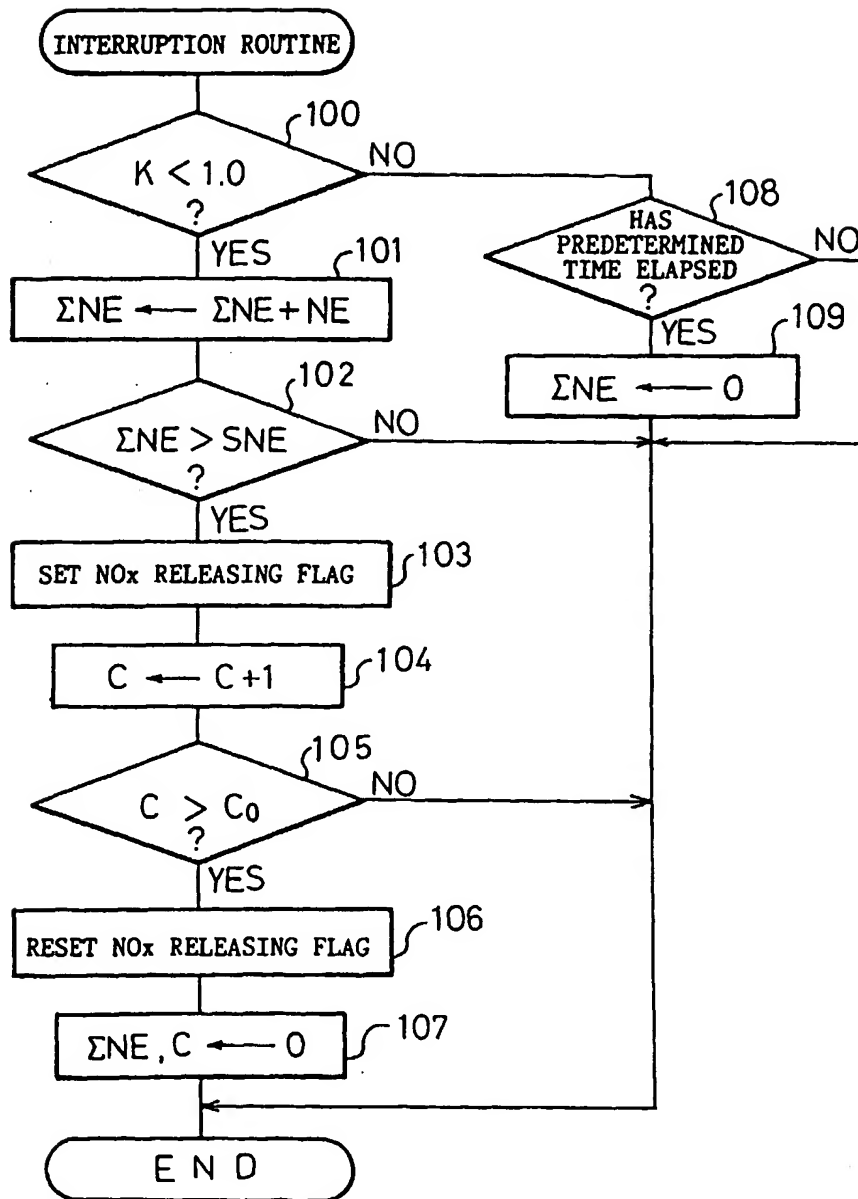


Fig. 8

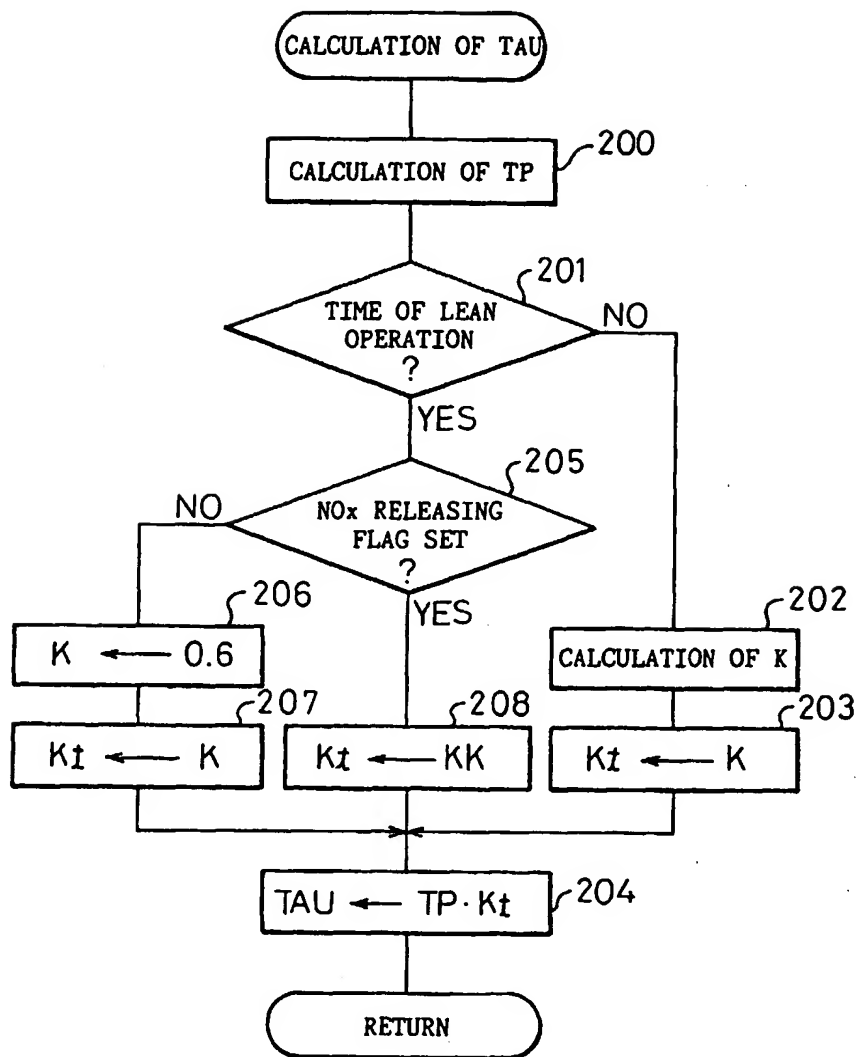


Fig.9

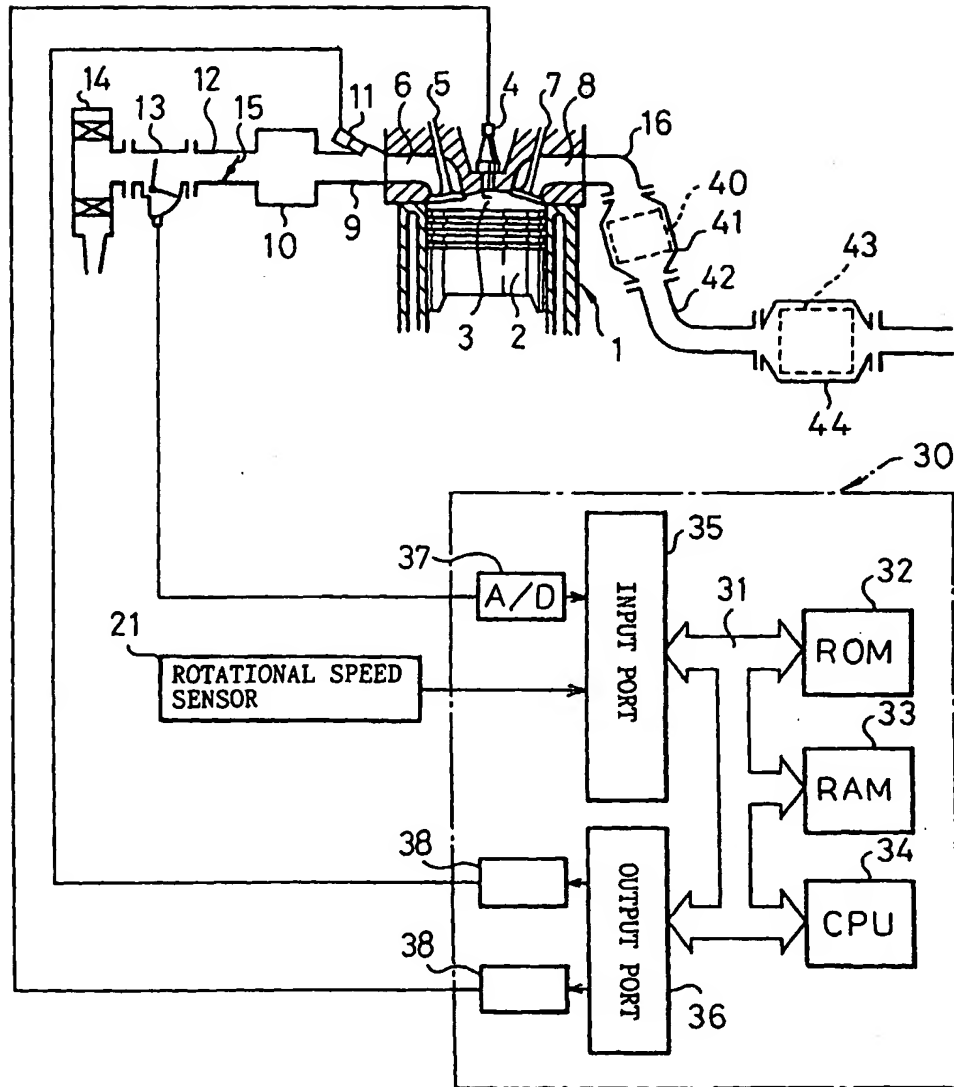




Fig.10

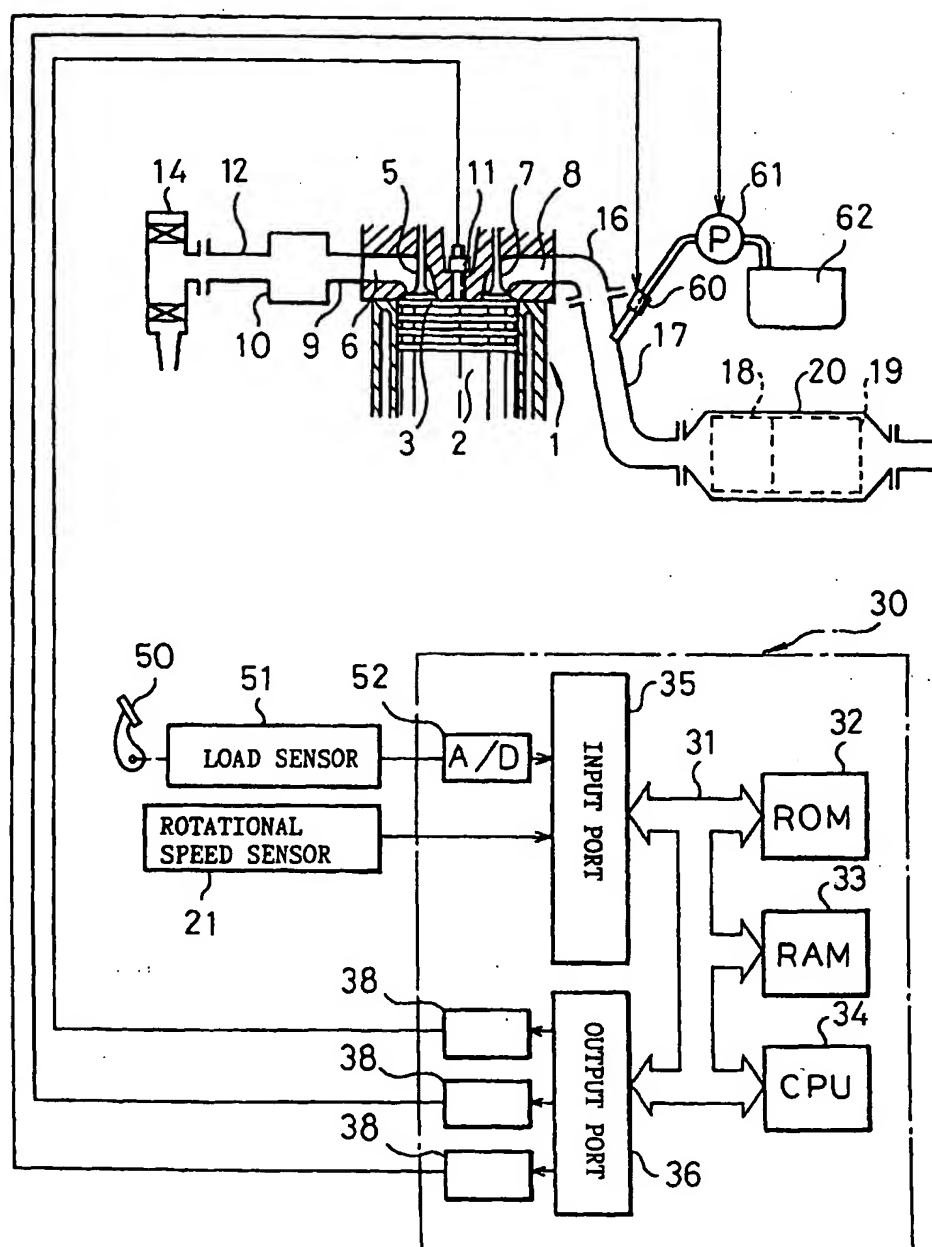


Fig.11

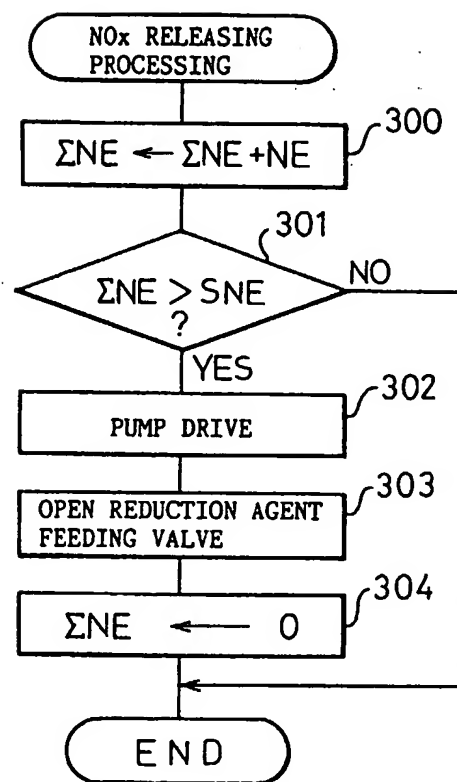


Fig.12

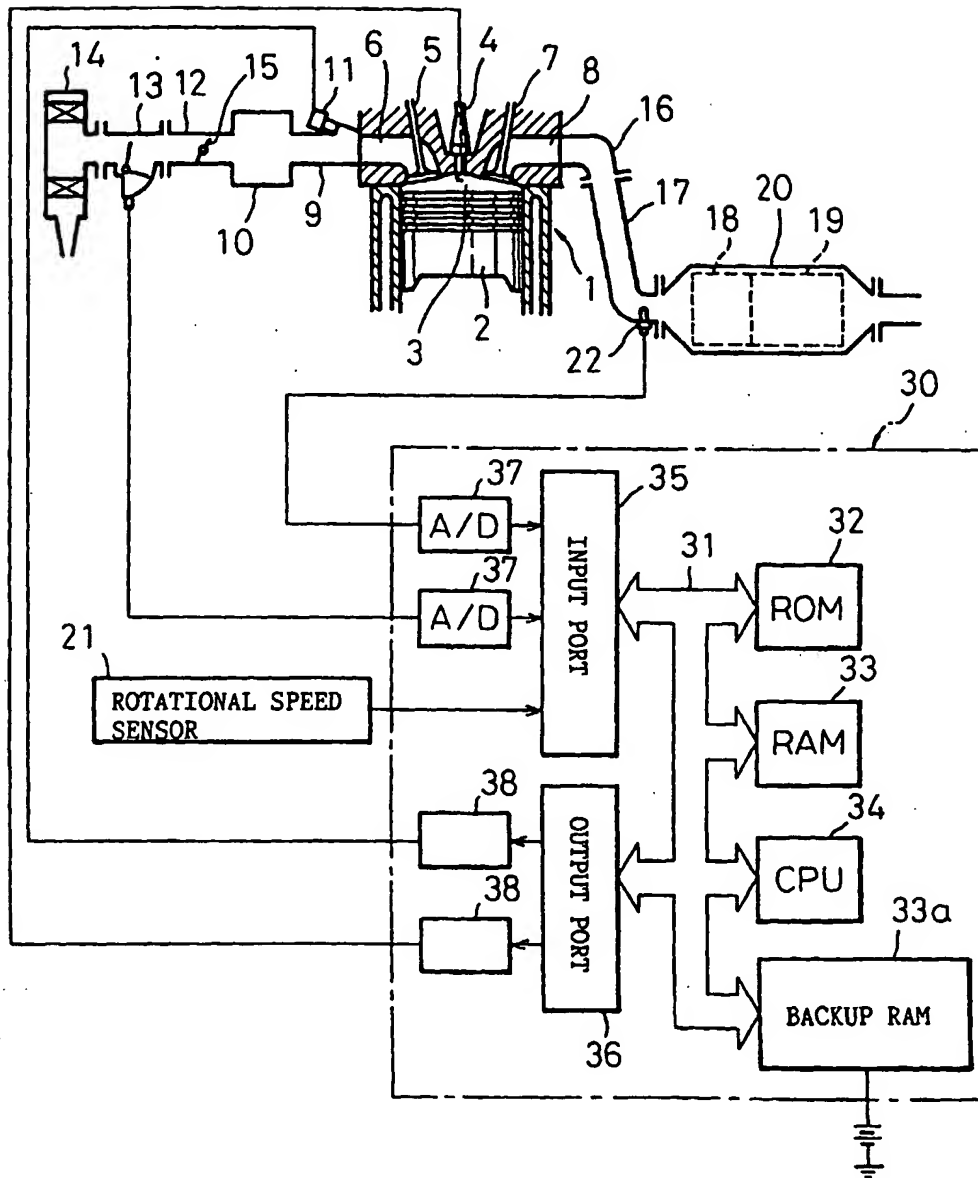


Fig.13

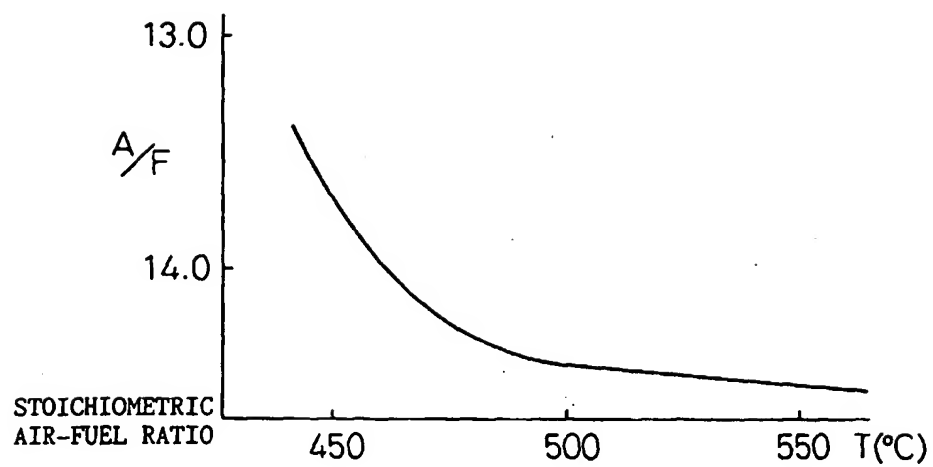


Fig.14

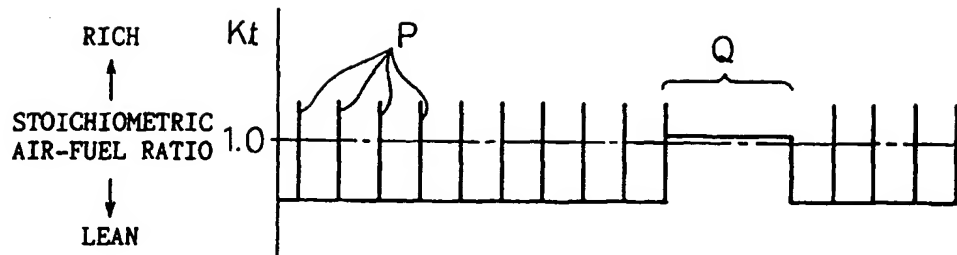


Fig.15

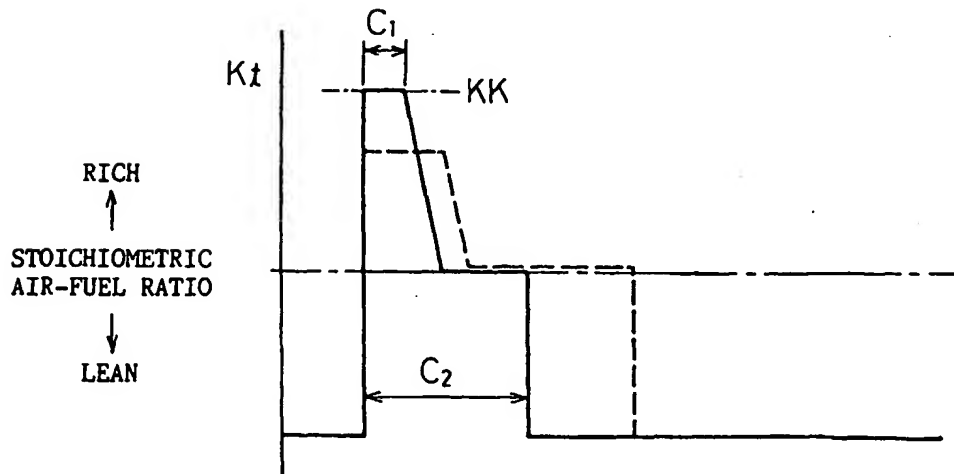


Fig.16A

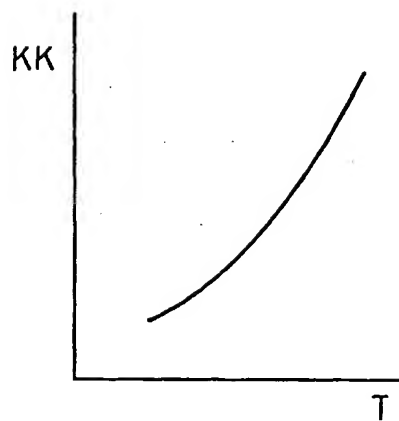


Fig.16B

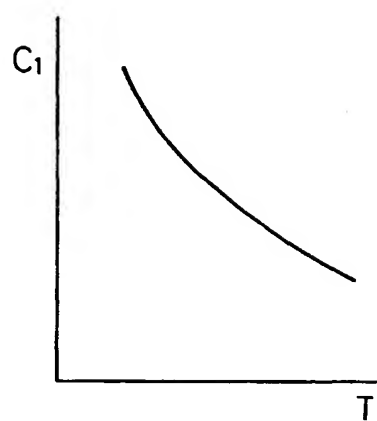


Fig.16C

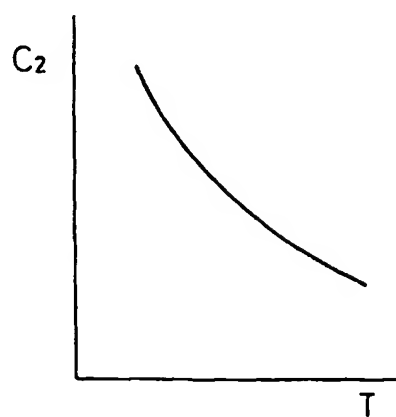


Fig.17

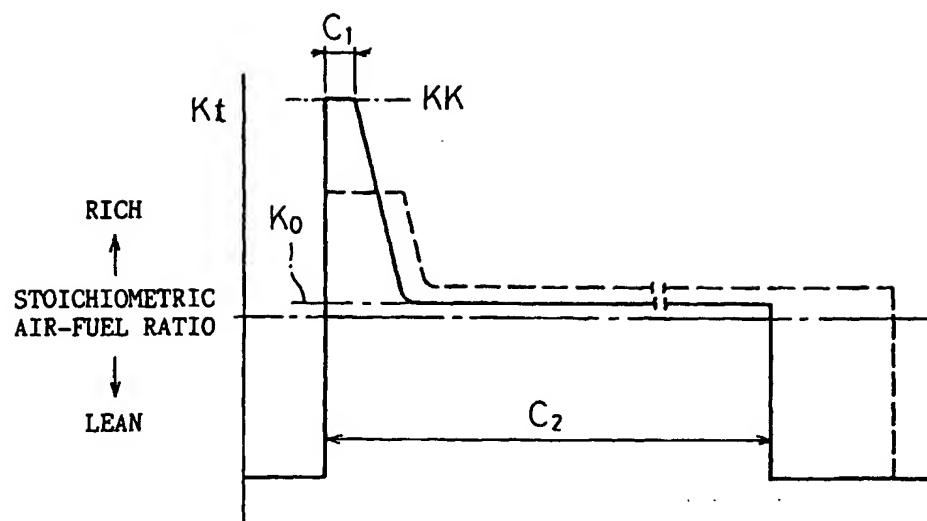




Fig.18A

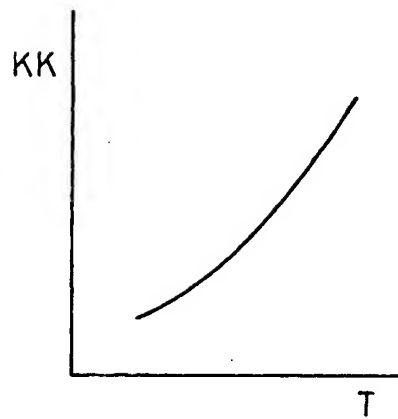


Fig.18B

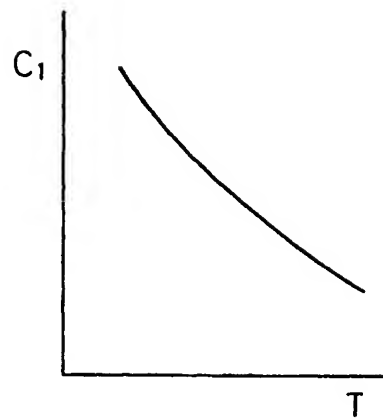


Fig.18C

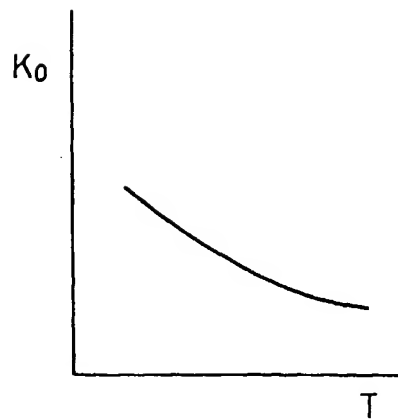


Fig.18D

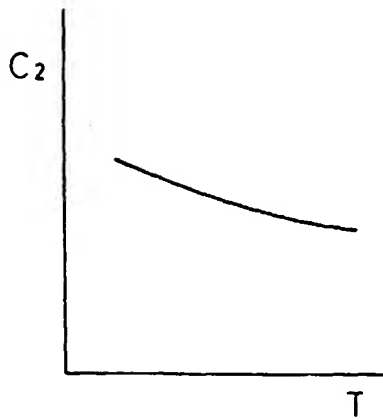


Fig.19

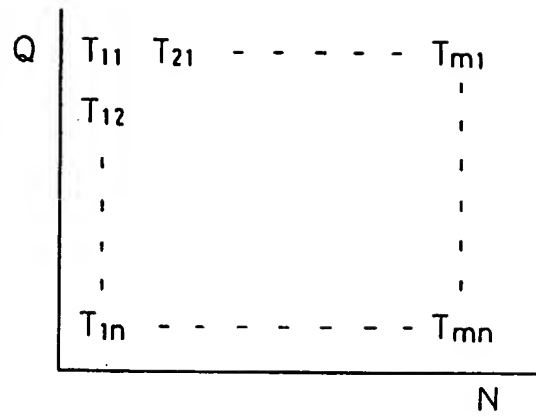


Fig. 20

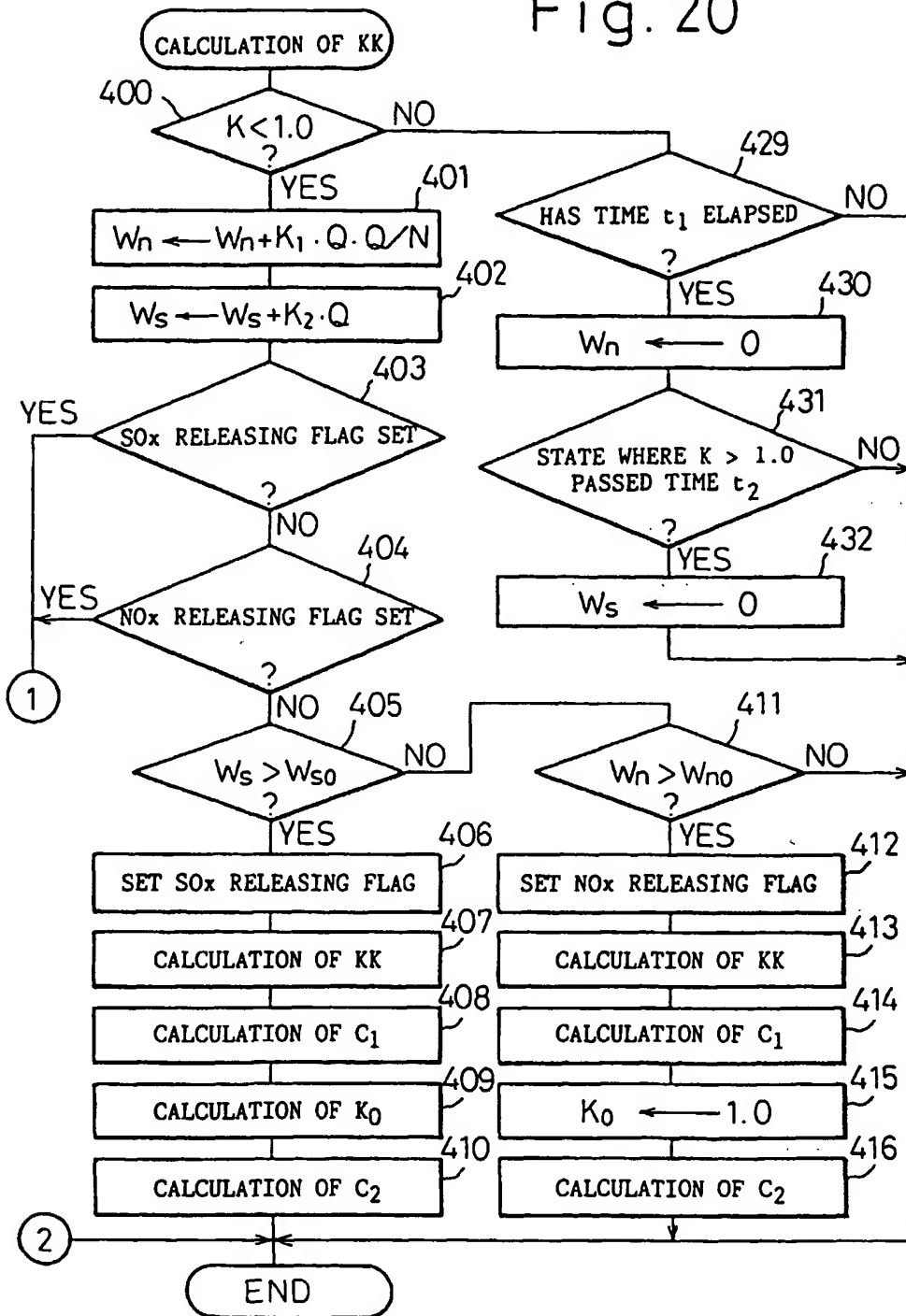


Fig.21

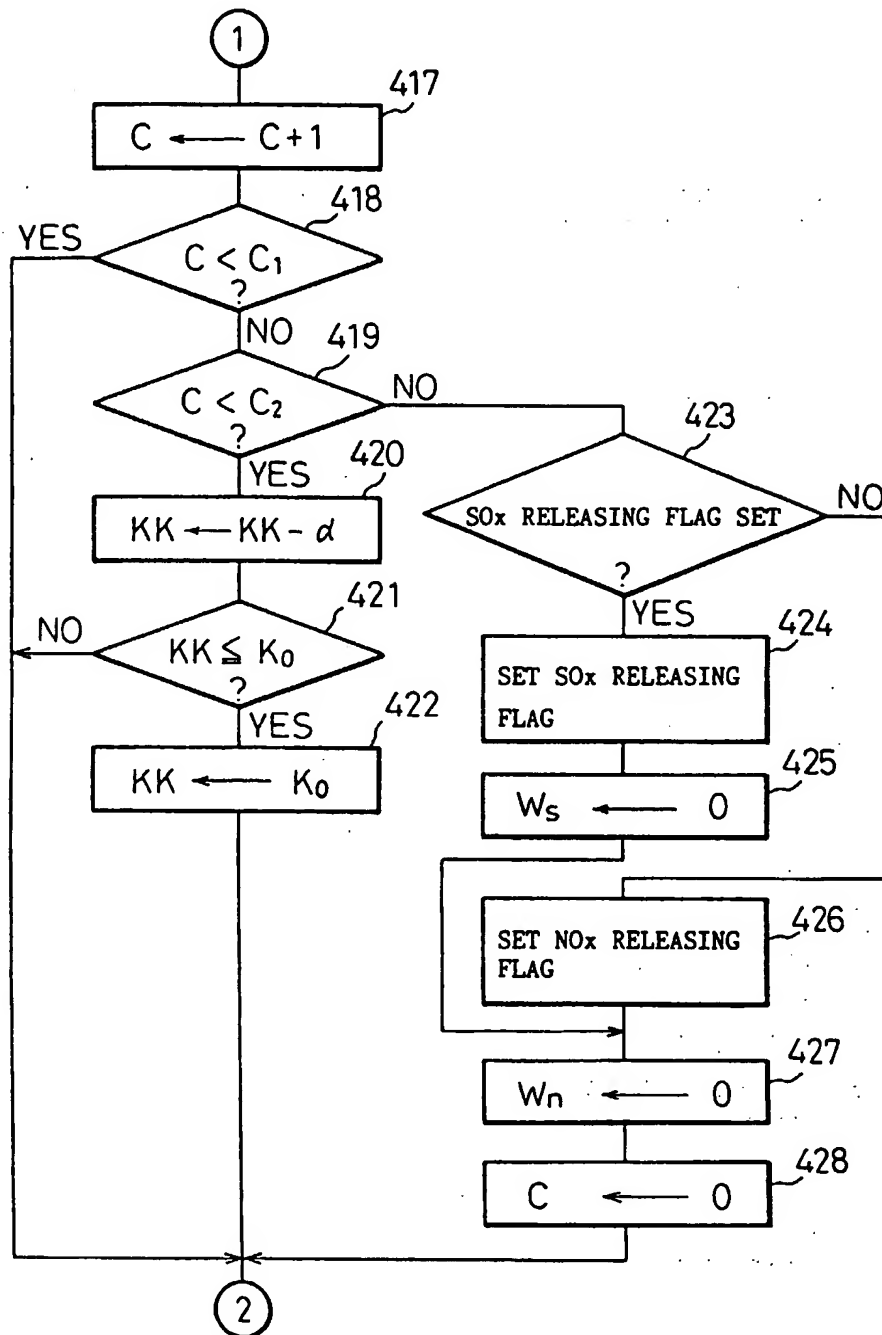


Fig. 22

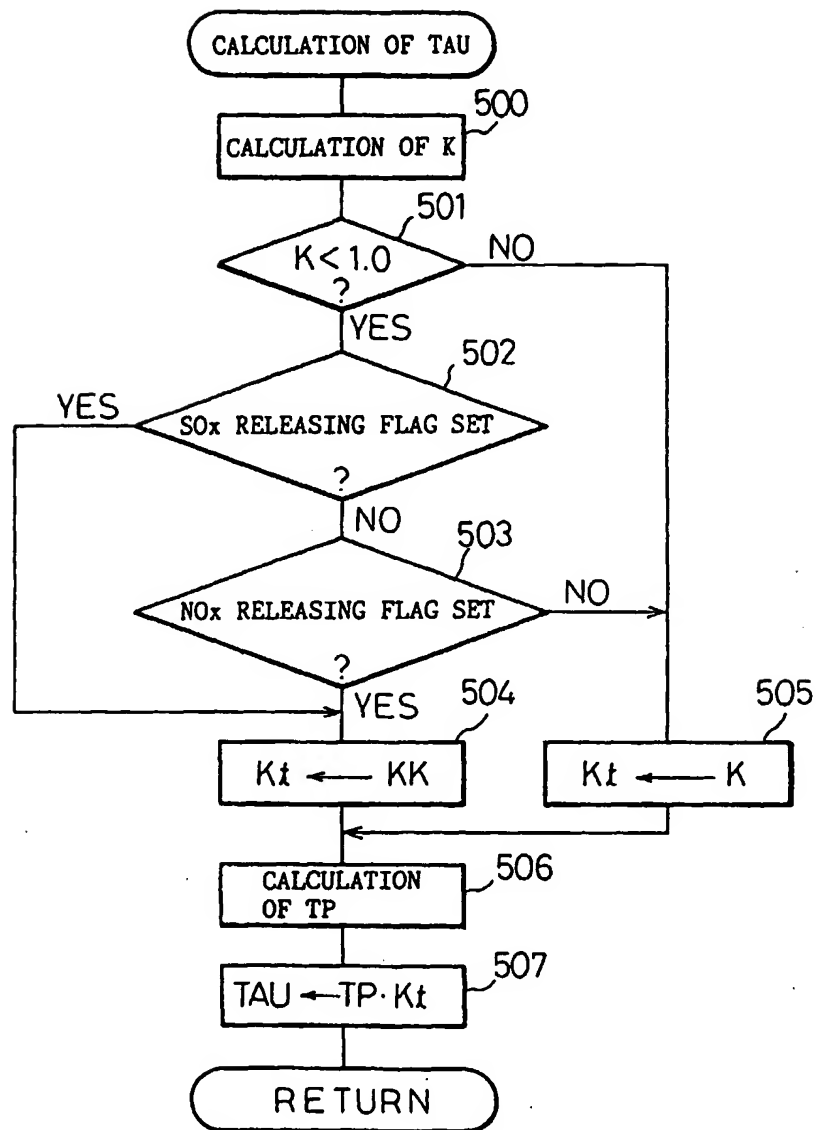


Fig. 23

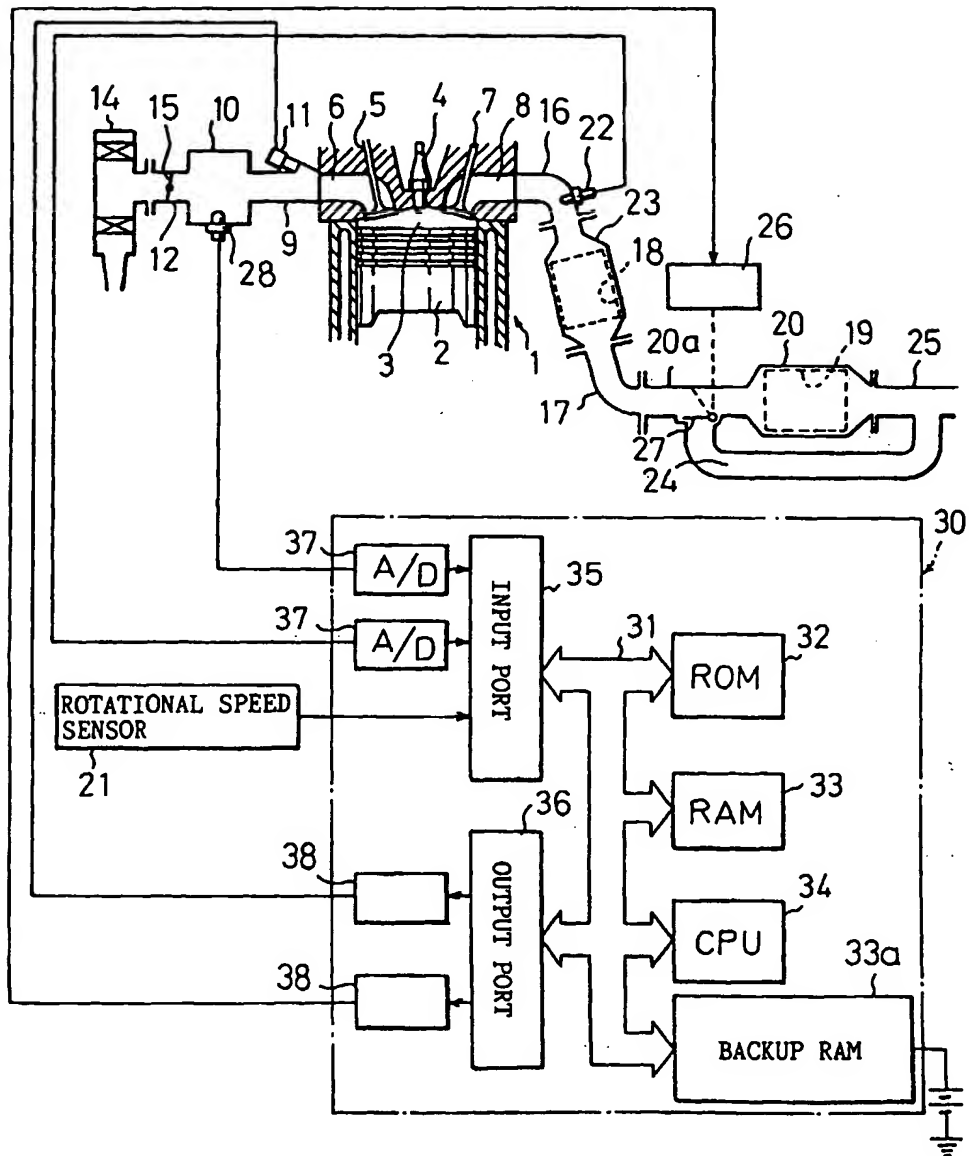


Fig. 24

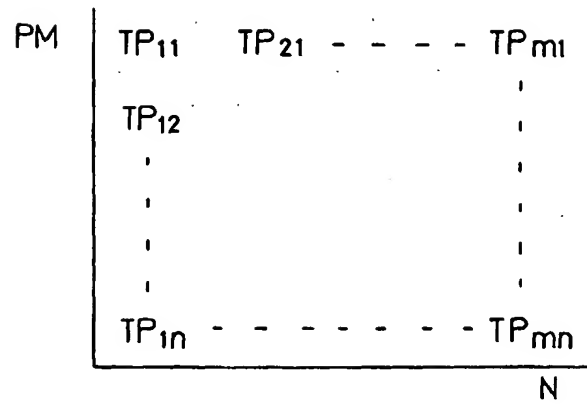


Fig. 25

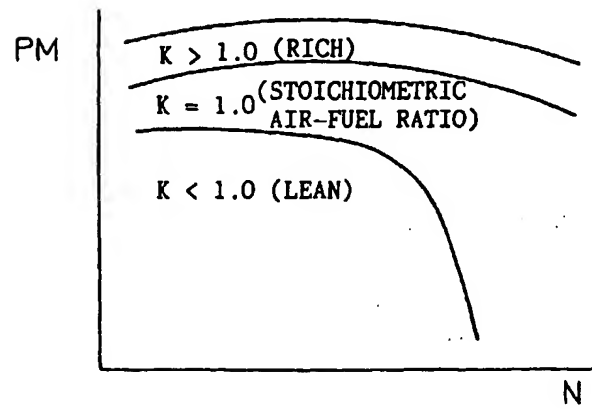




Fig.26A

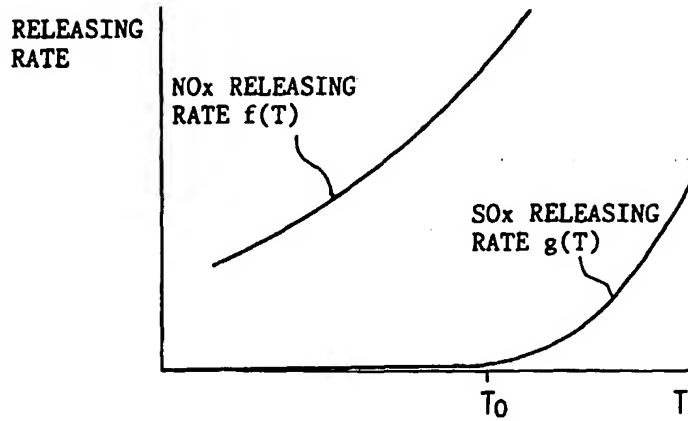


Fig.26B

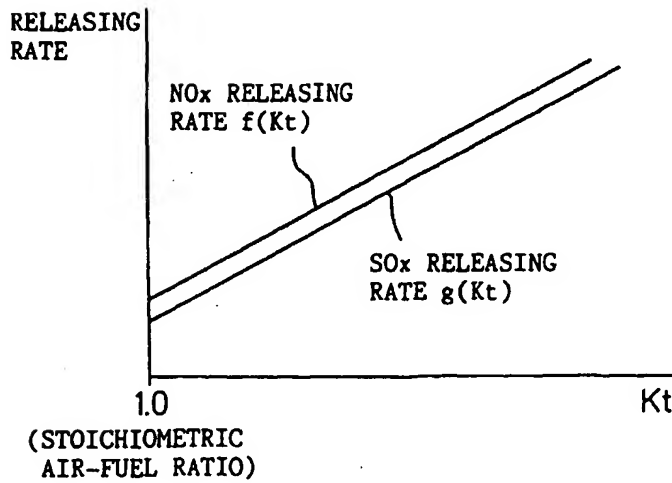


Fig. 27A

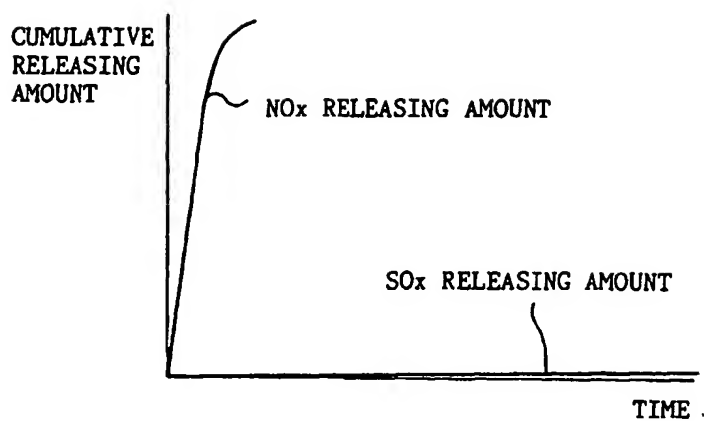


Fig. 27B

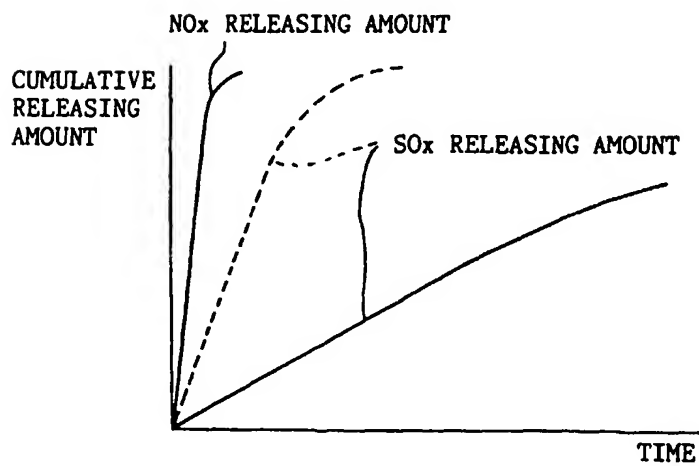


Fig. 28

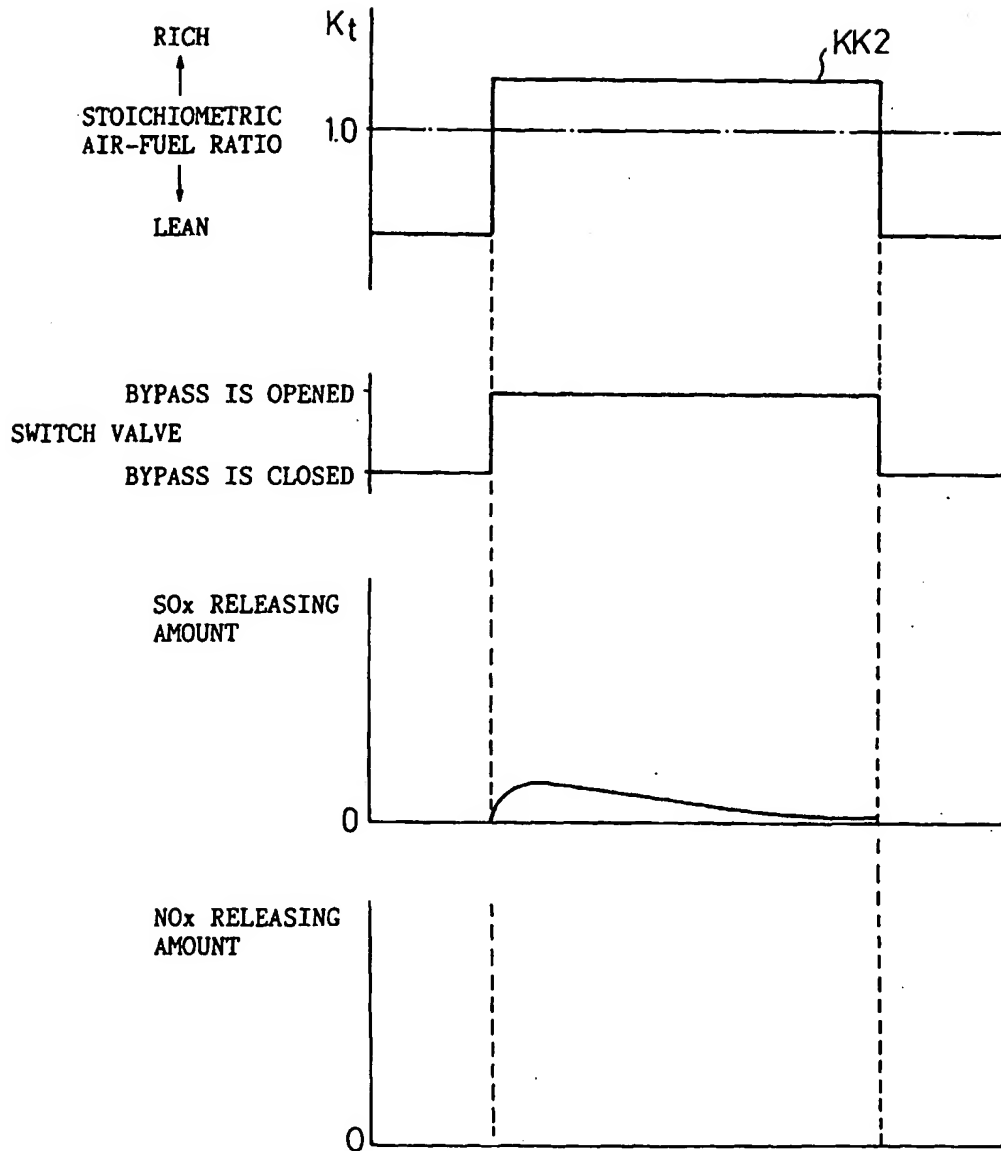


Fig. 29

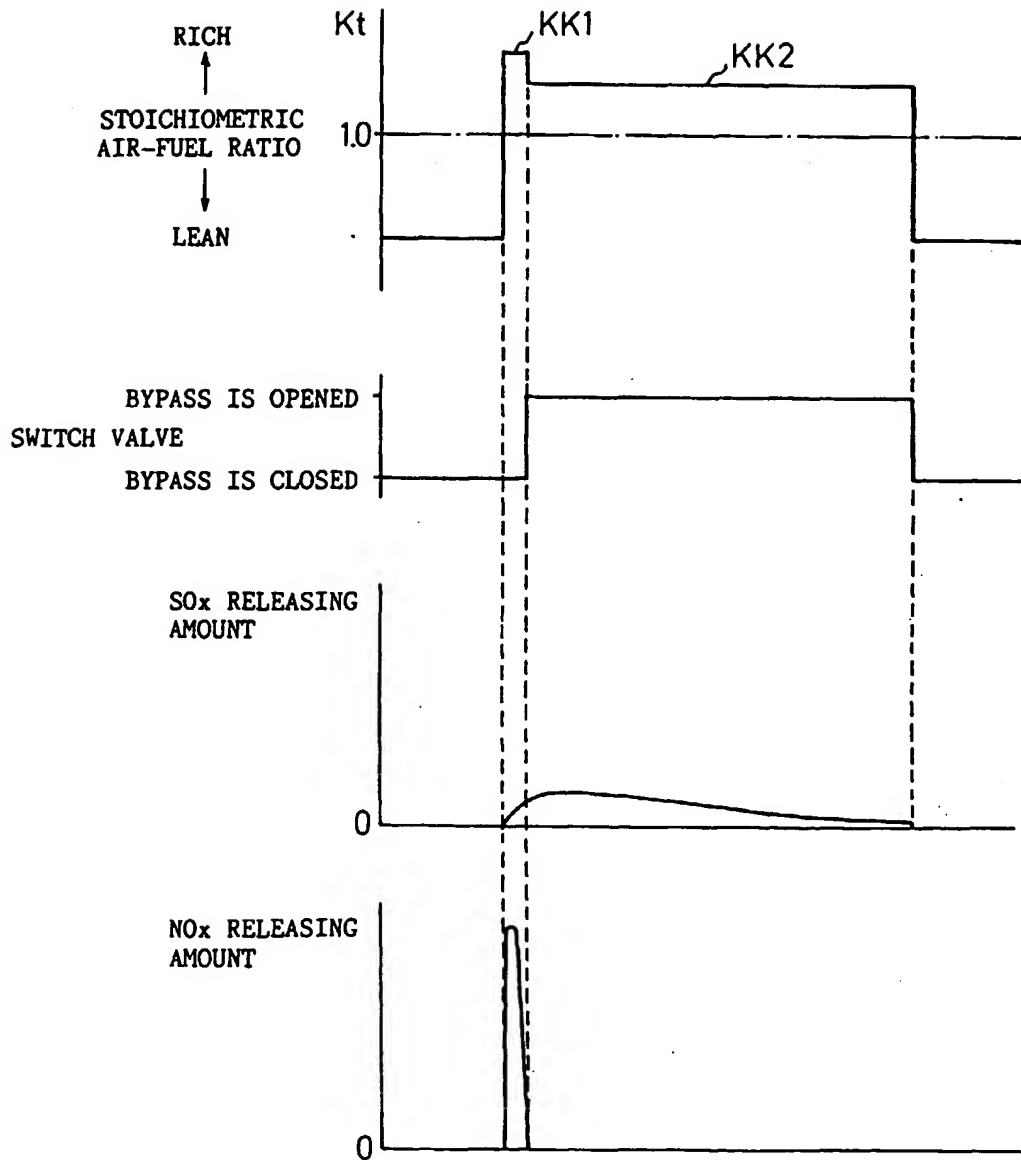


Fig. 30

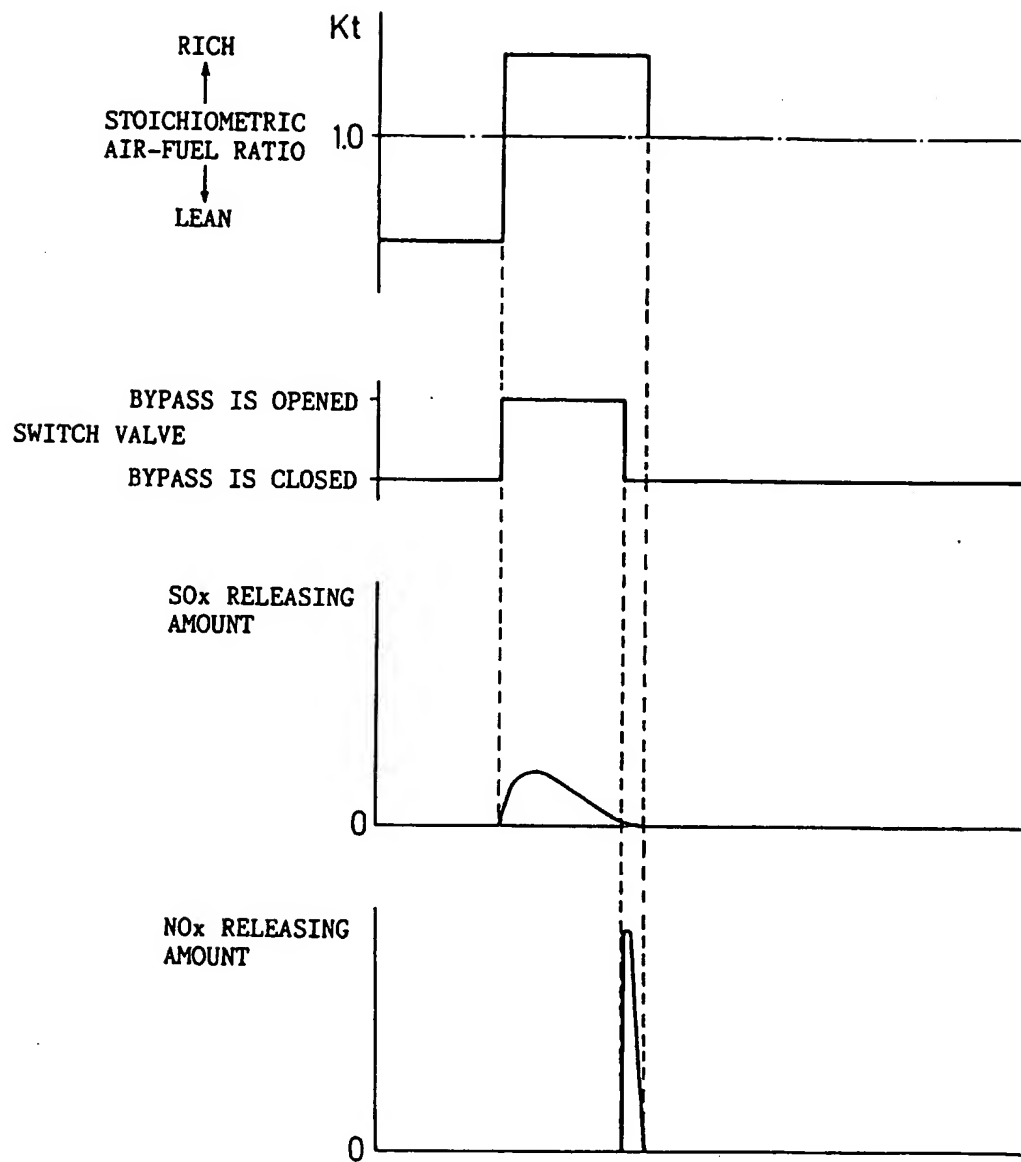


Fig. 31

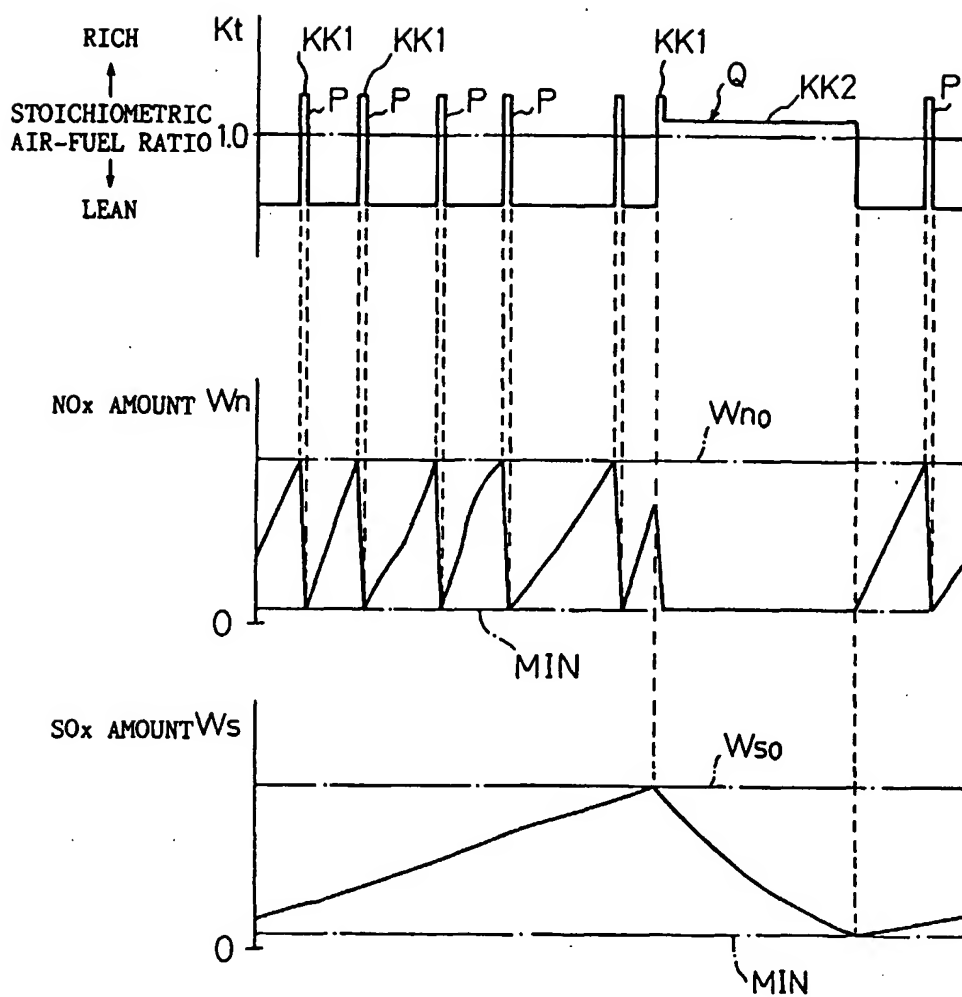


Fig. 32A

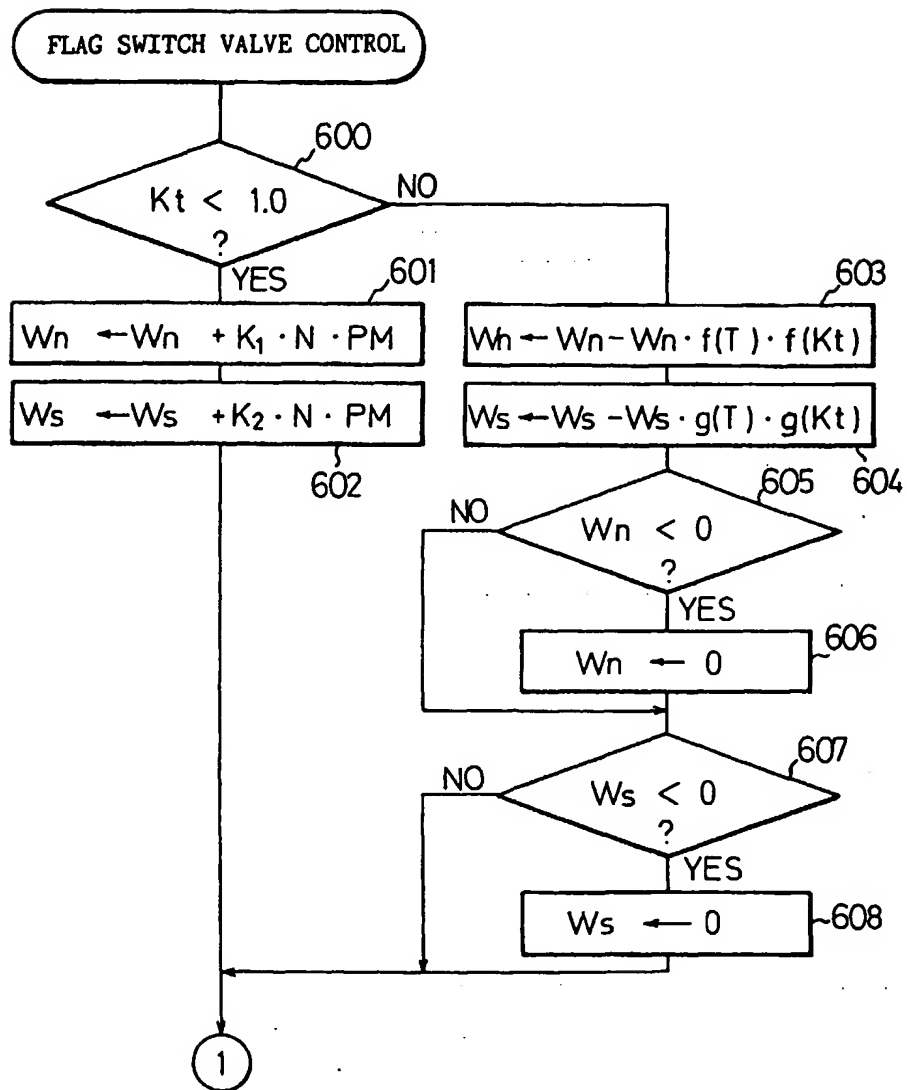




Fig.32B

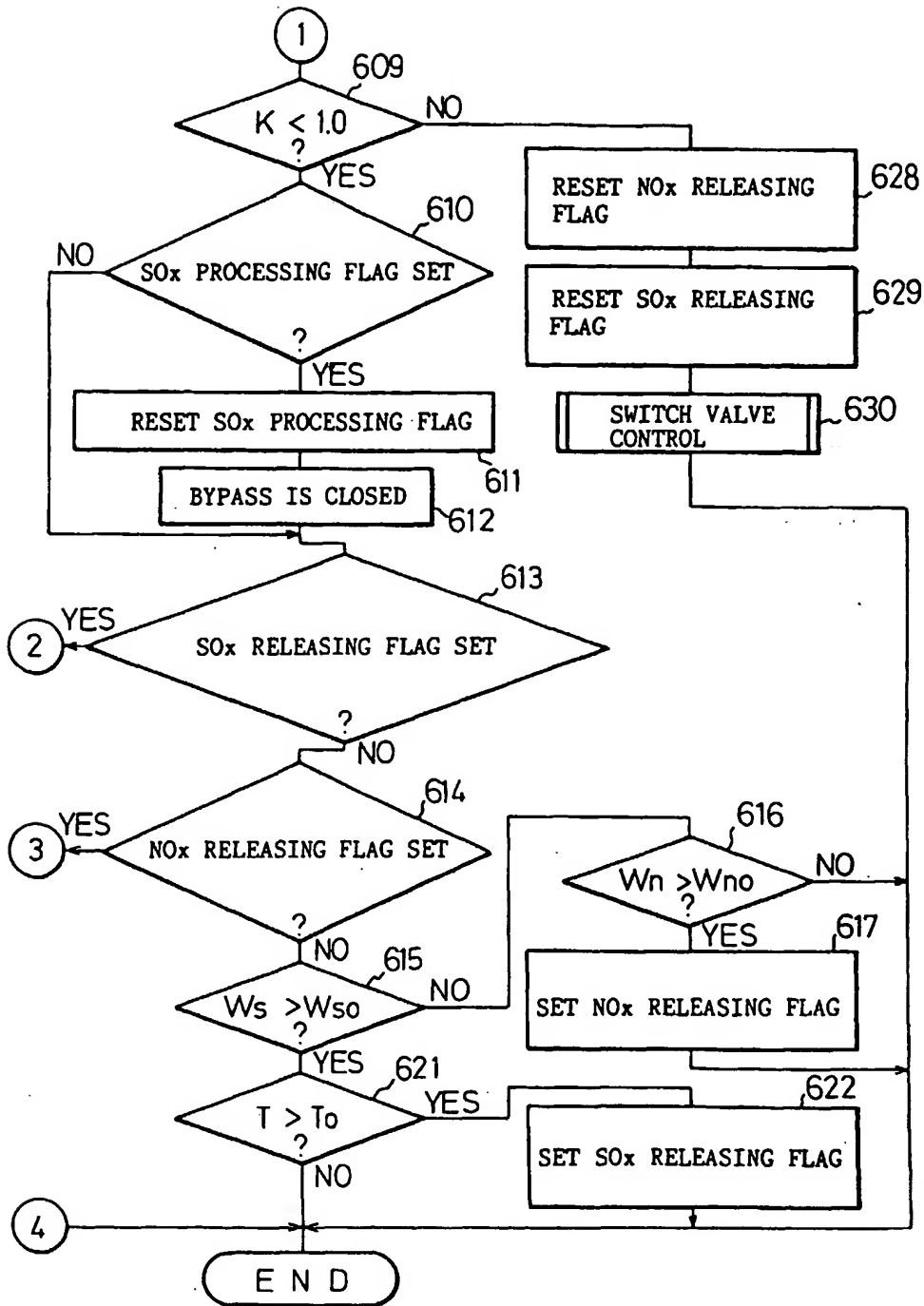


Fig.32C

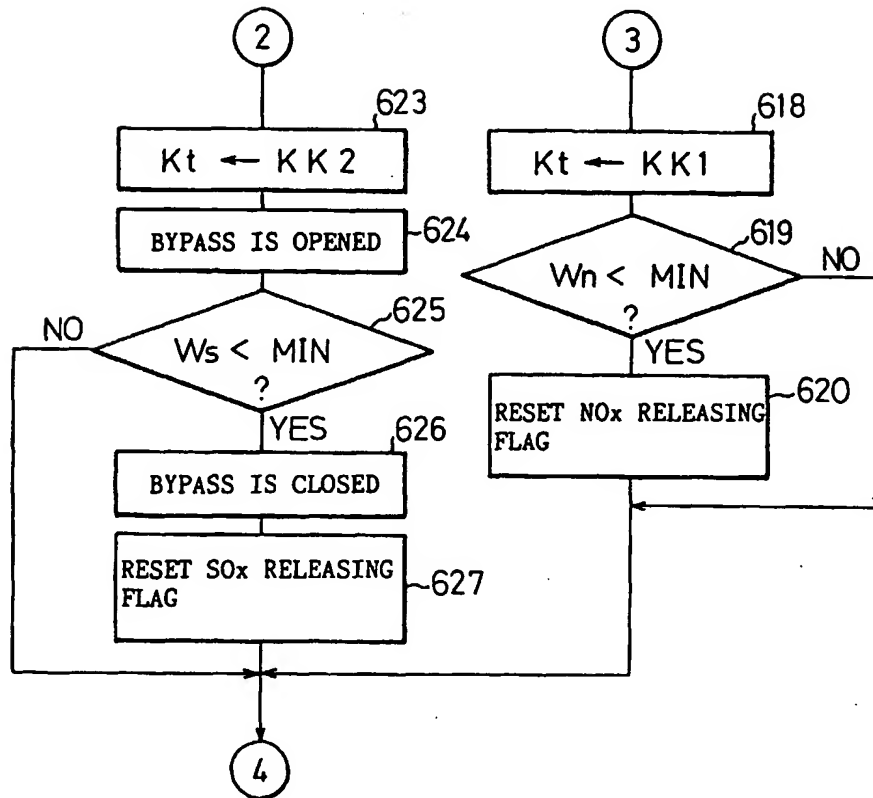


Fig.32D

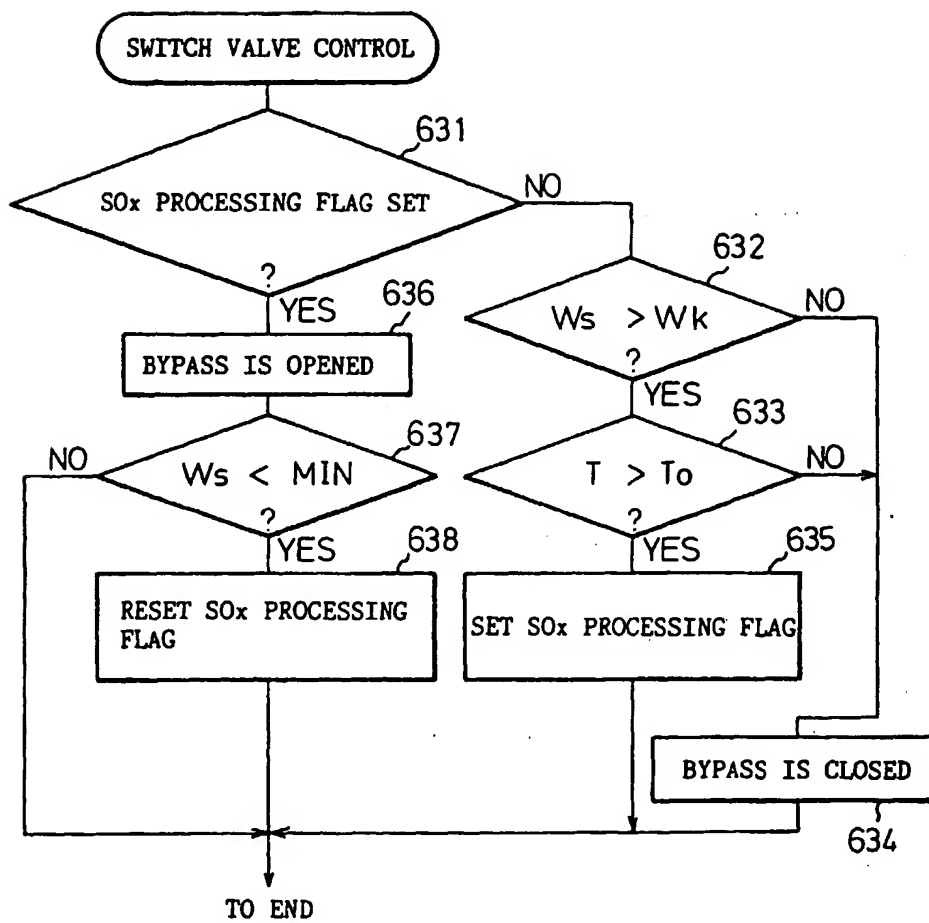


Fig.33

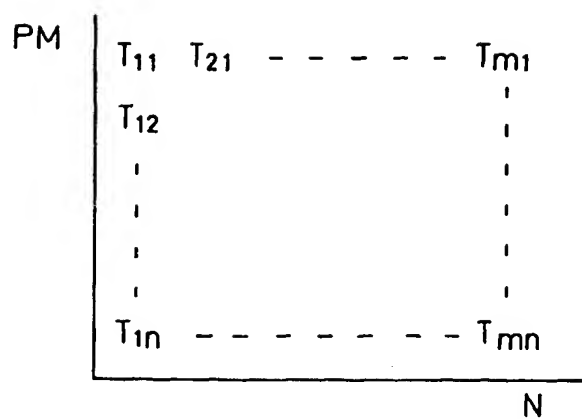


Fig. 34

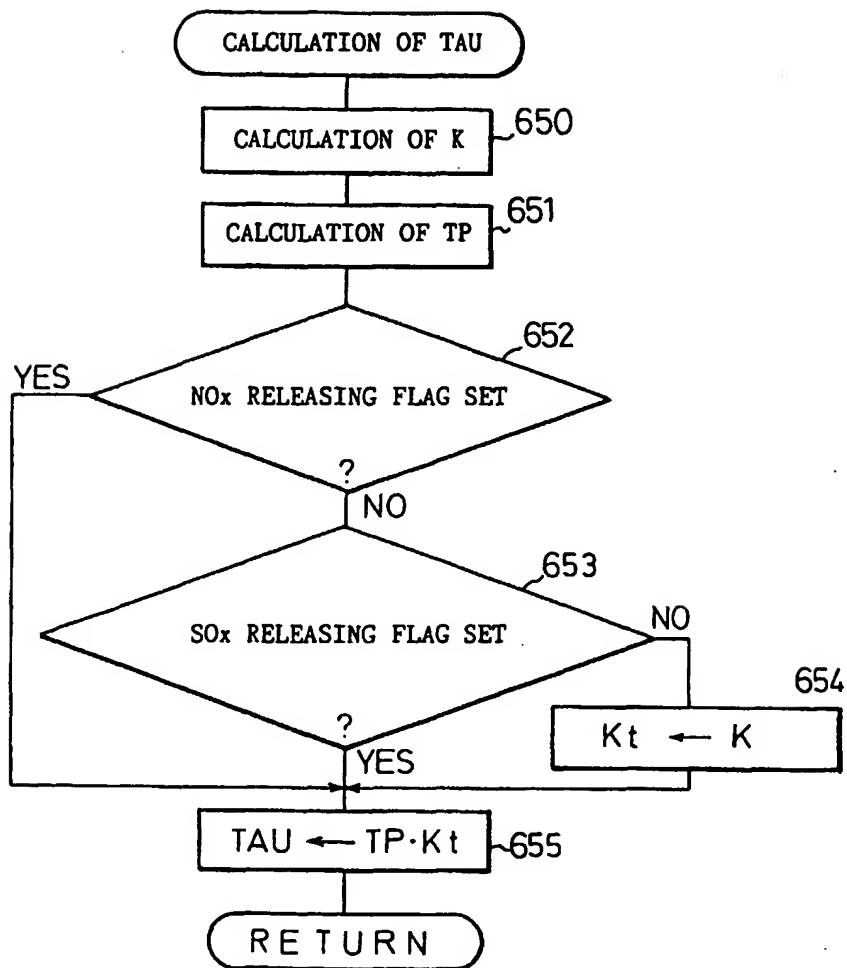


Fig. 35A

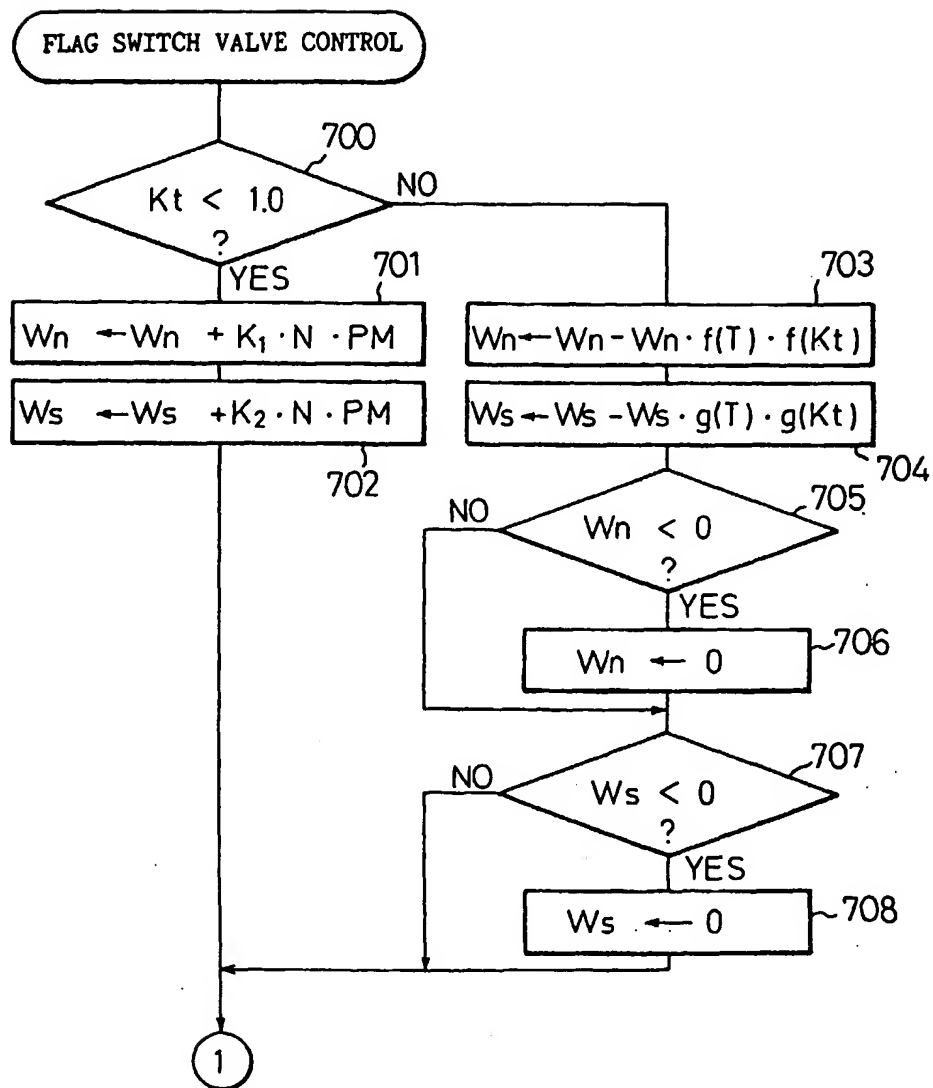


Fig. 35B

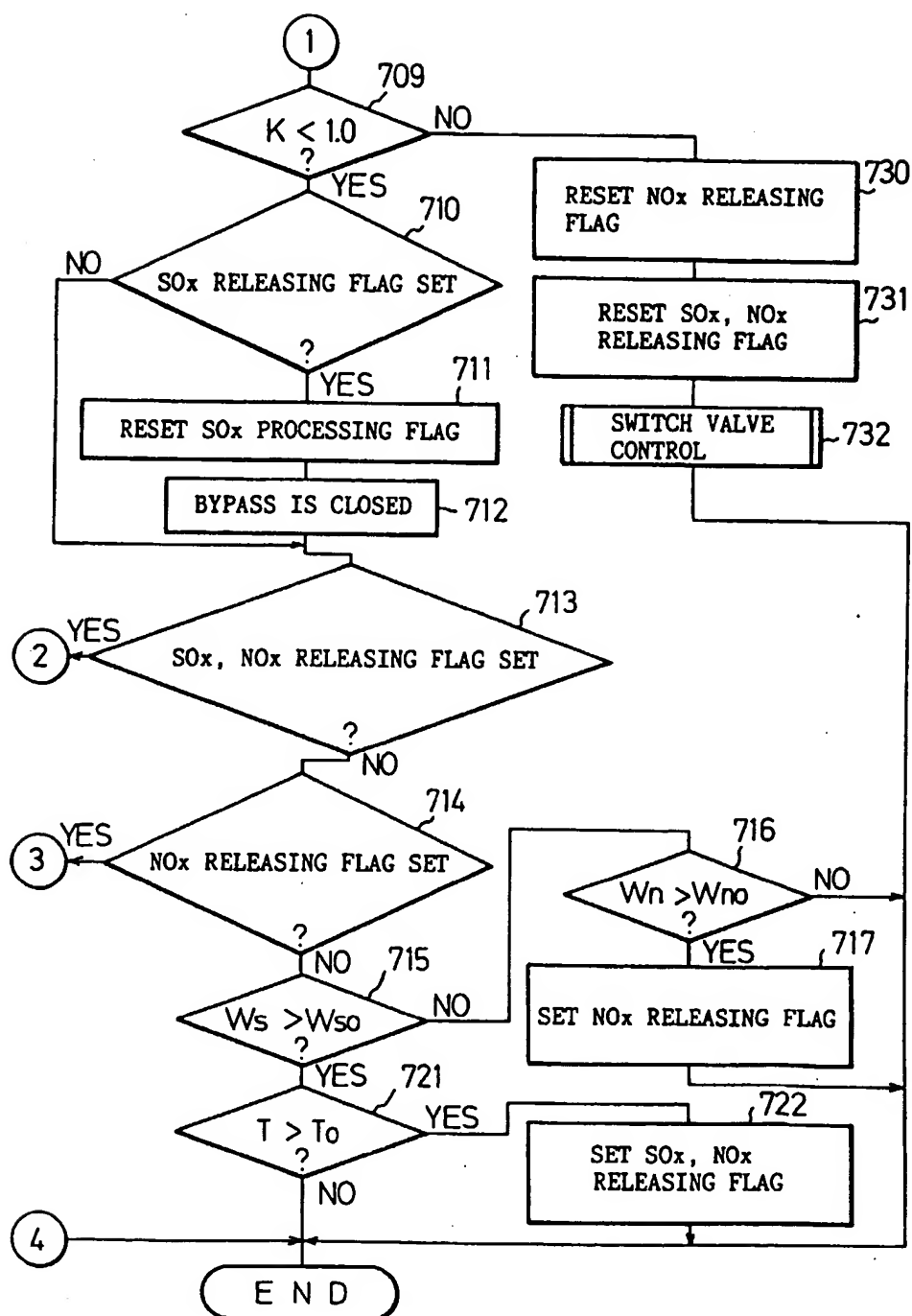


Fig. 35C

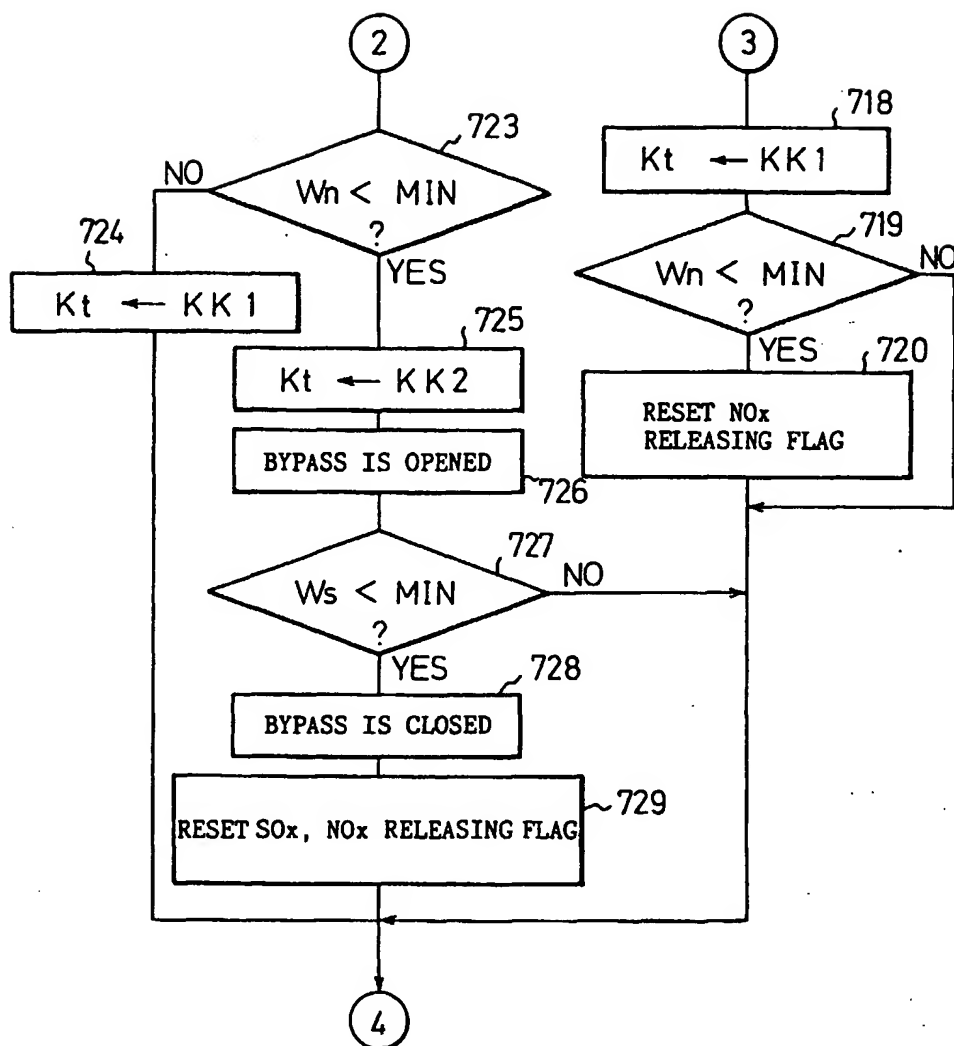




Fig. 35D

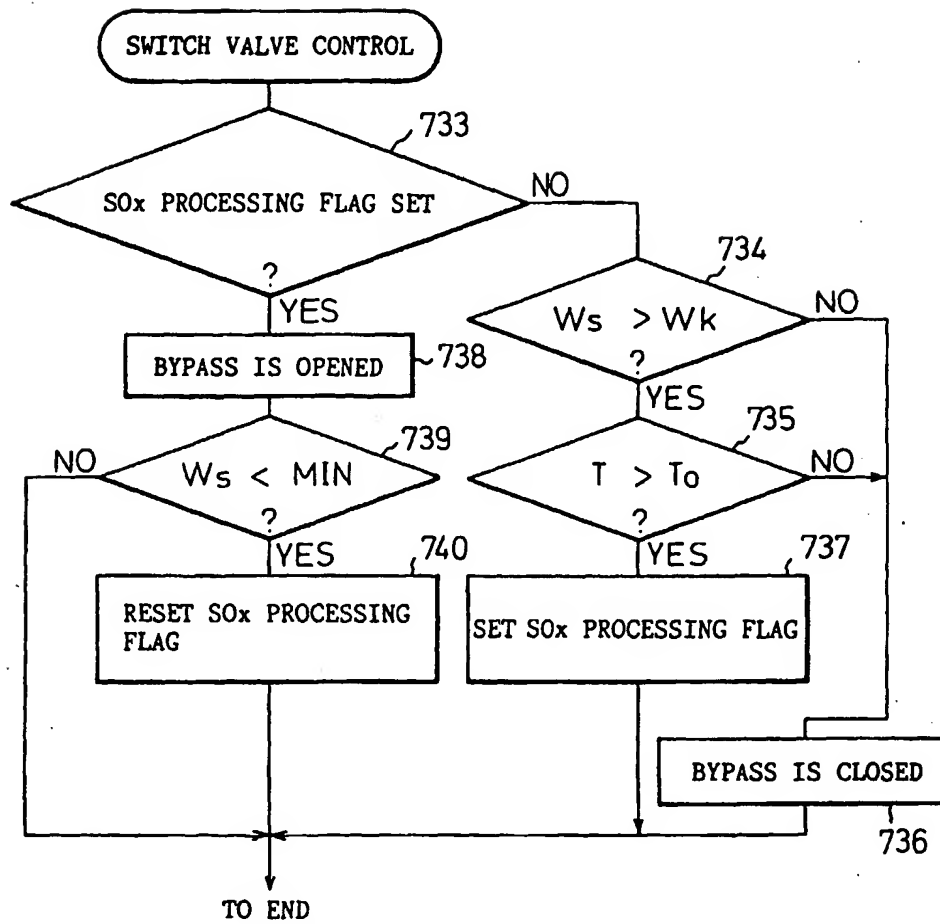


Fig.36

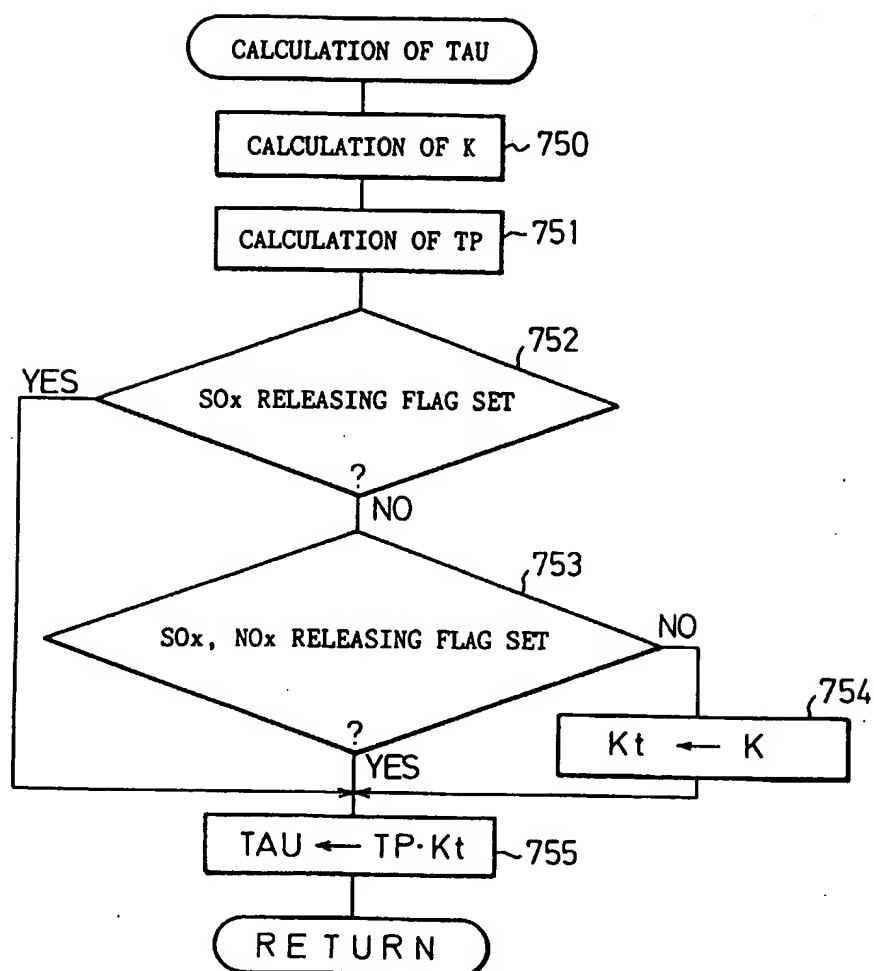


Fig. 37A

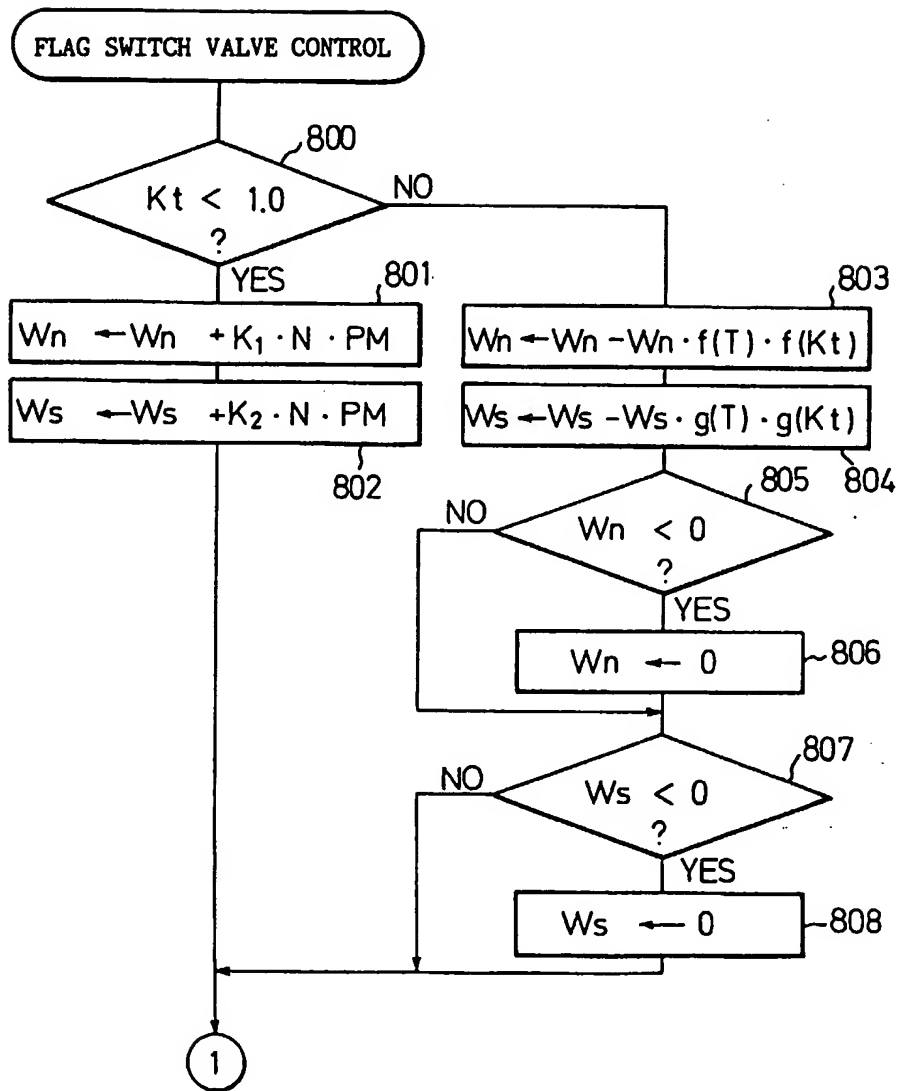


Fig. 37B

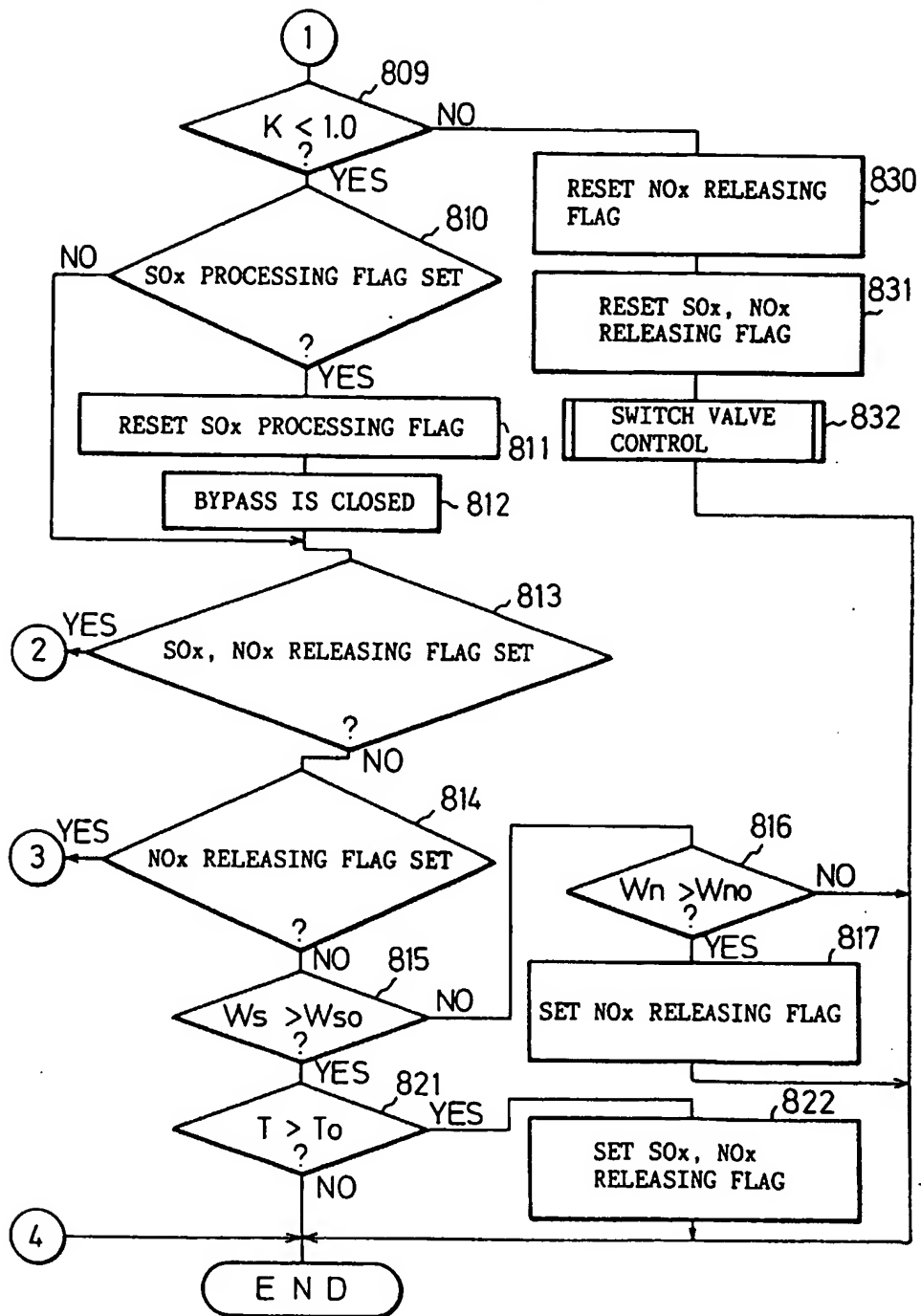


Fig.37C

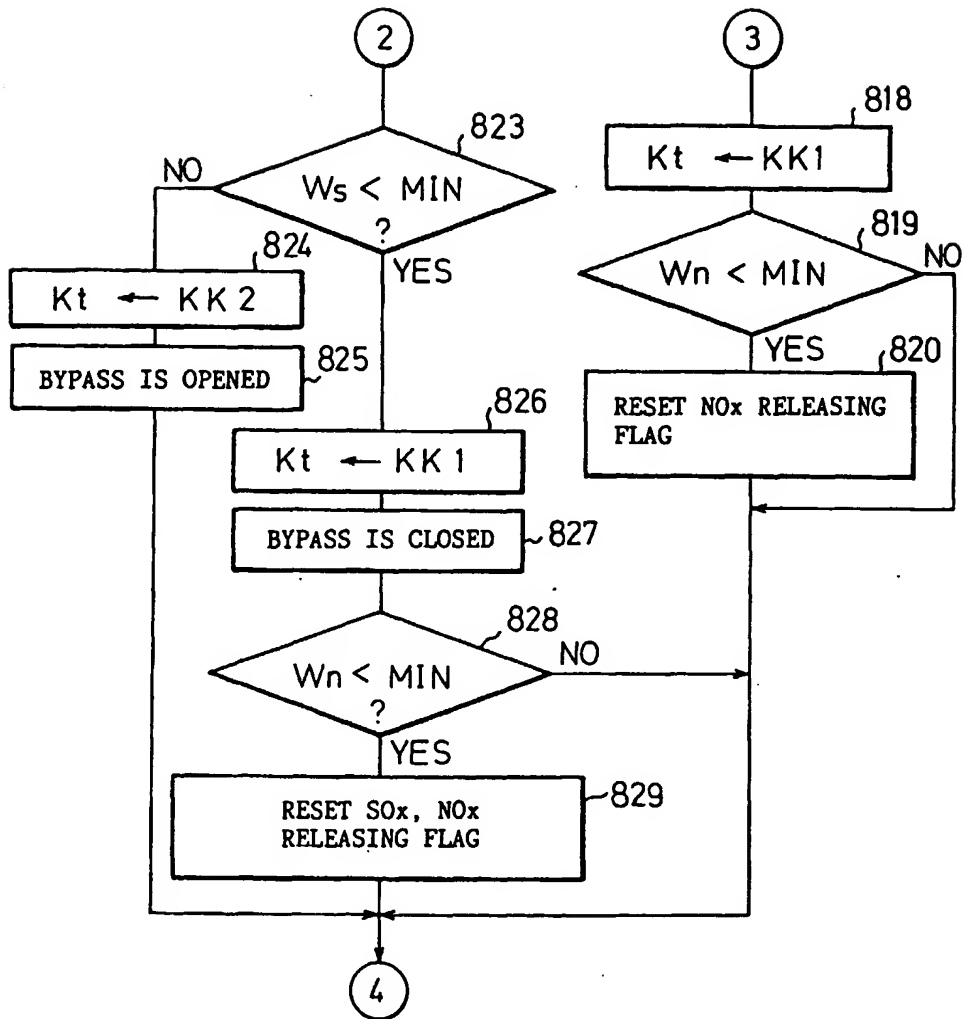


Fig. 37D

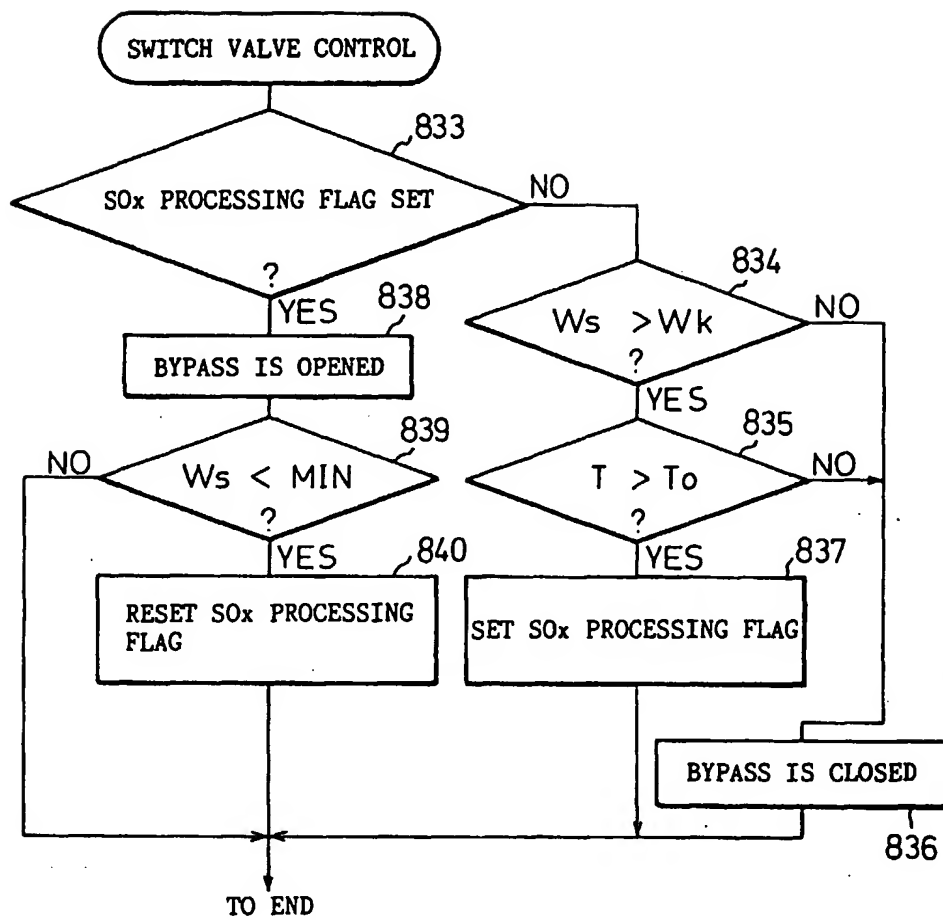


Fig. 38

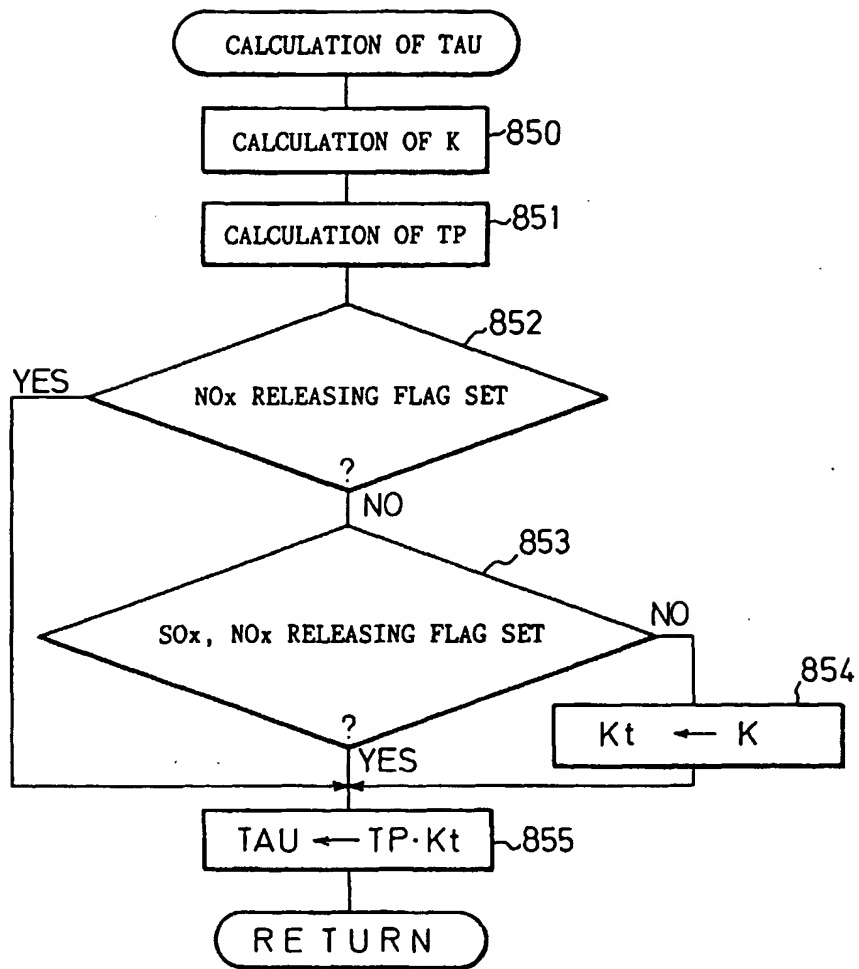


Fig. 39A

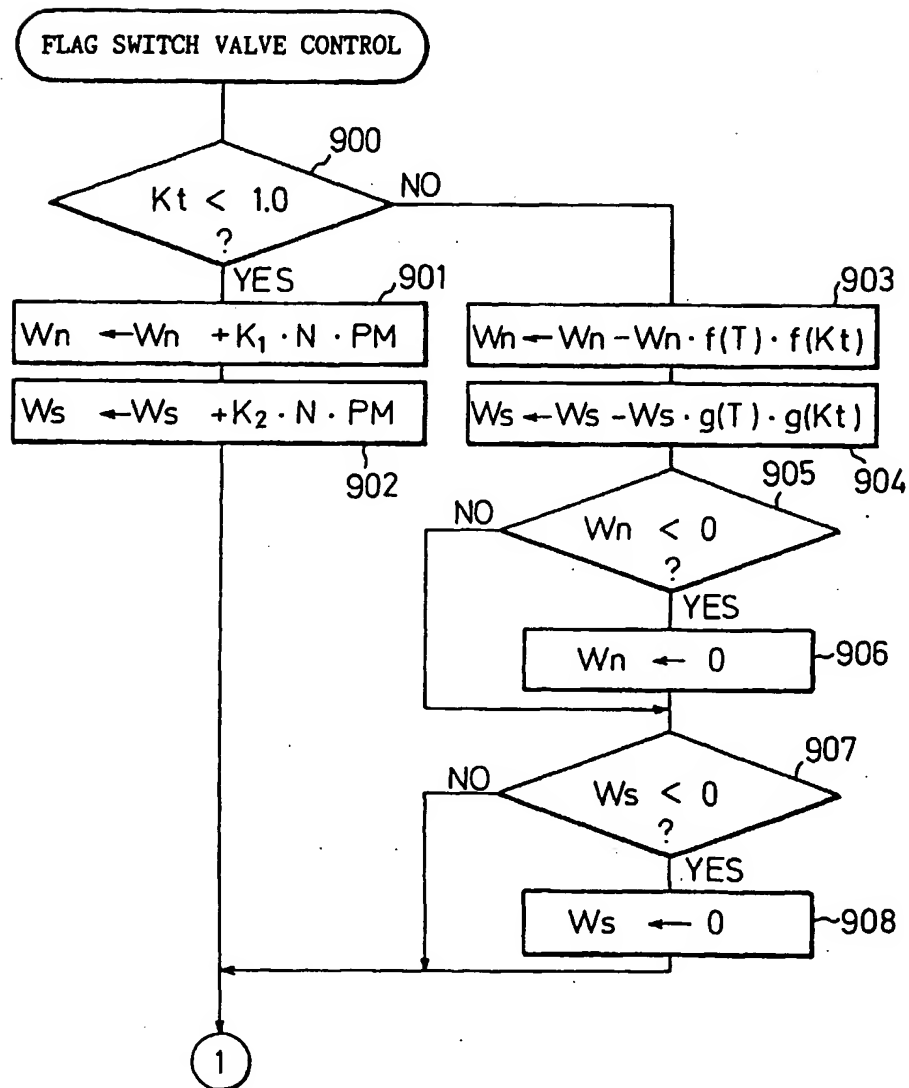




Fig.39B

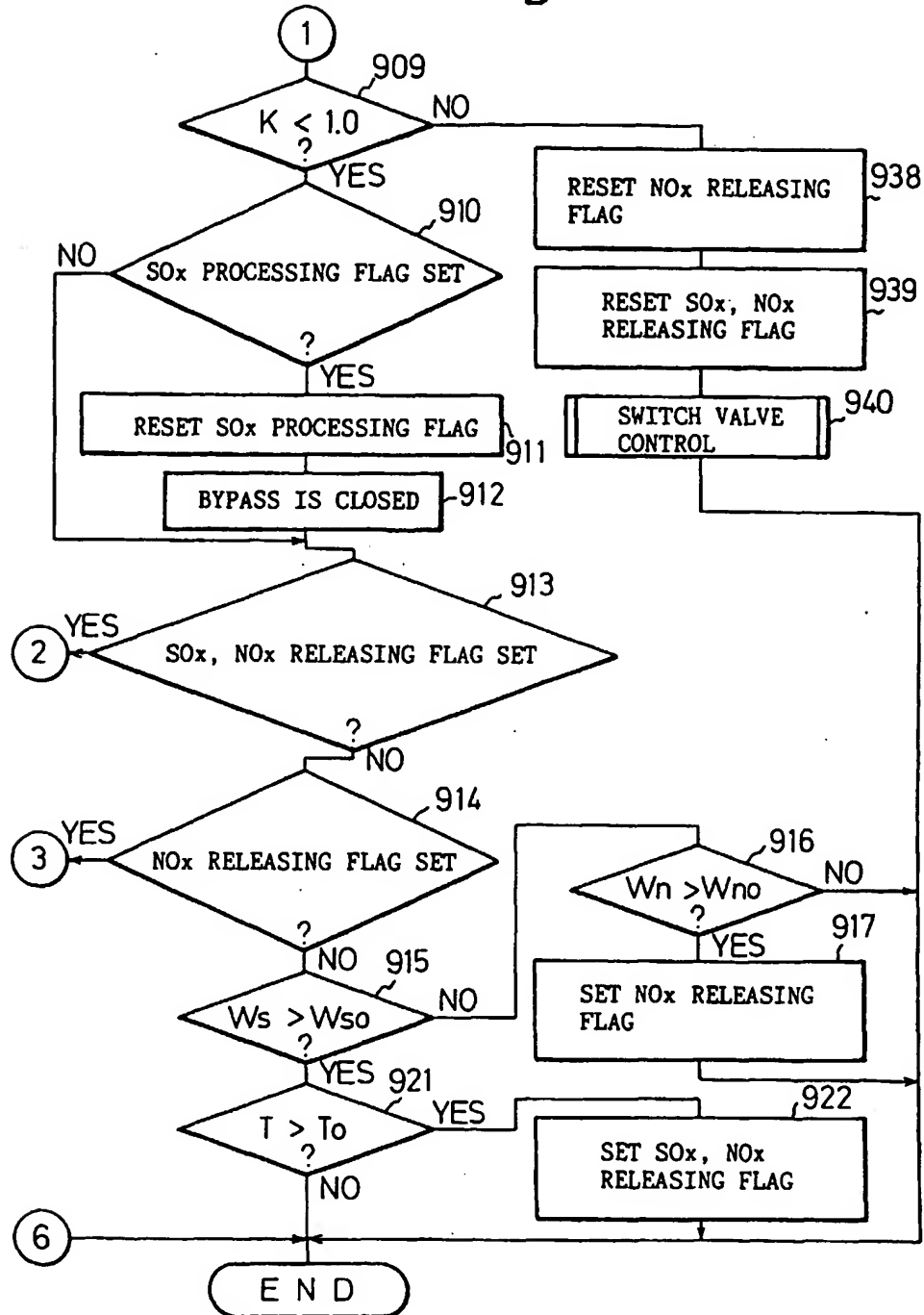


Fig. 39C

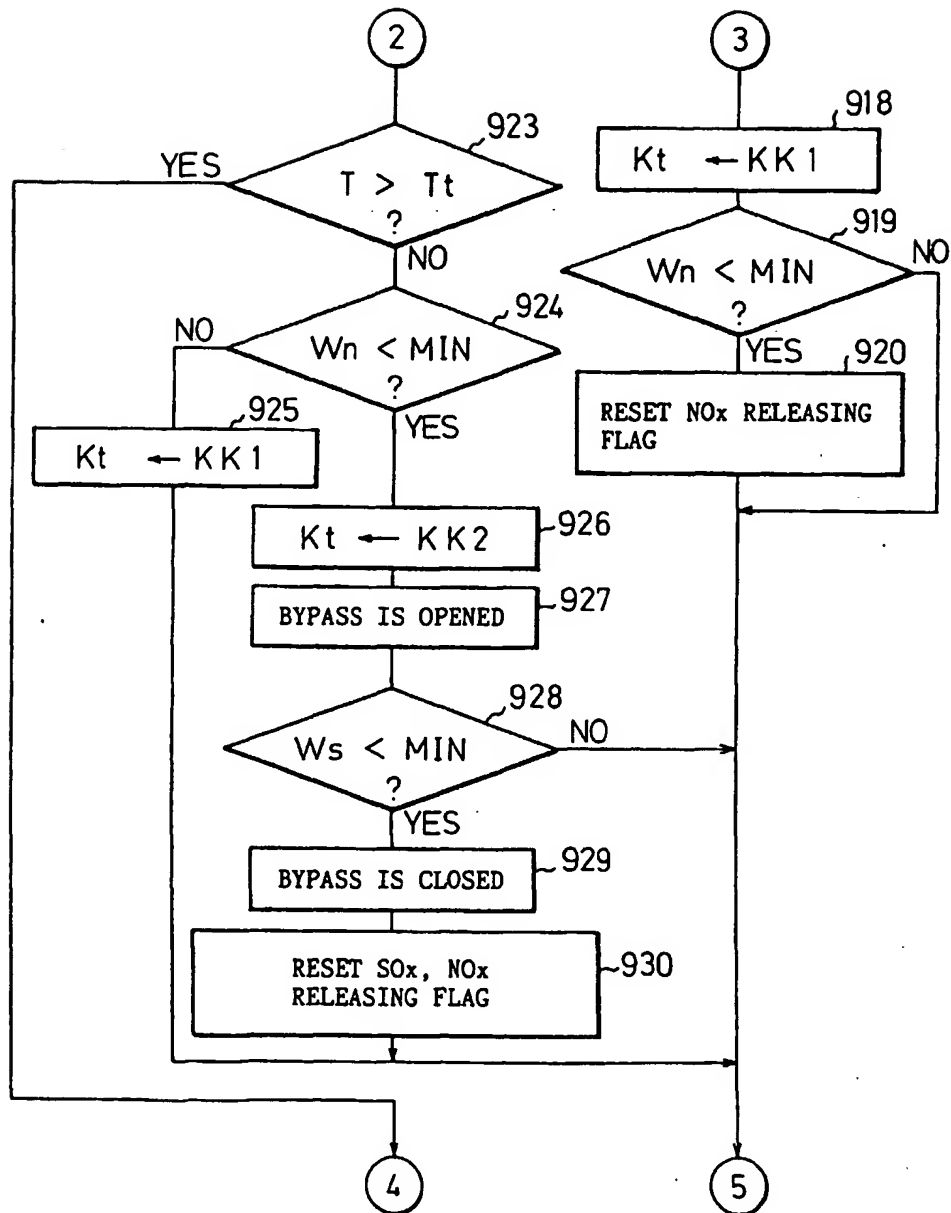


Fig. 39D

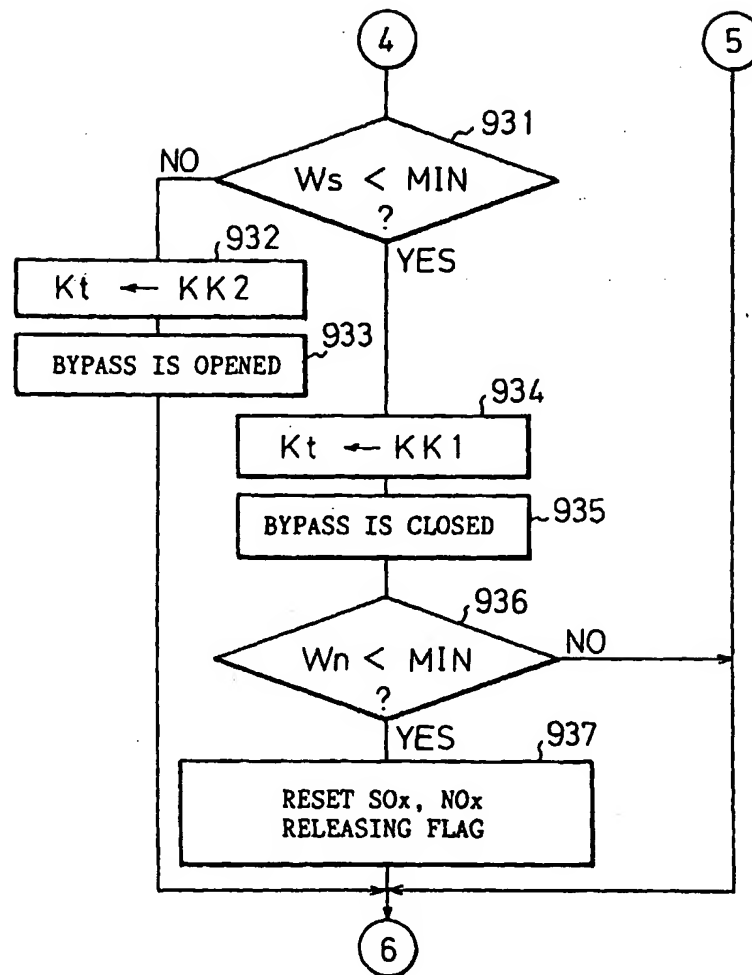


Fig. 39E

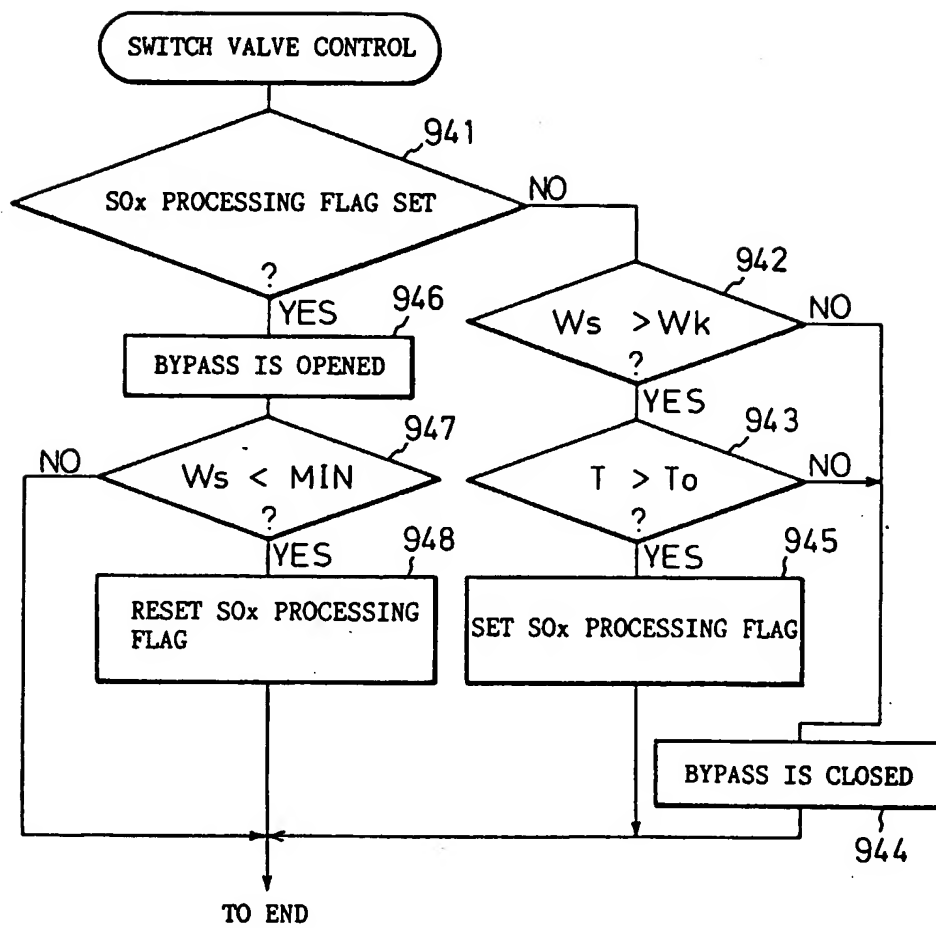
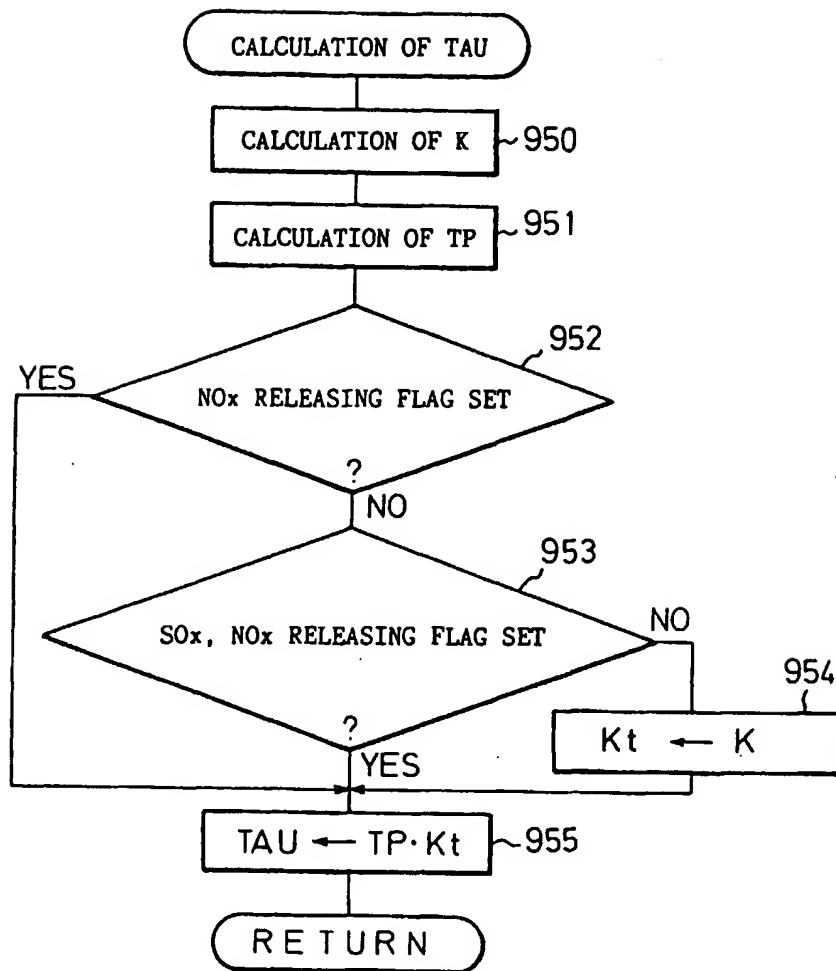


Fig. 40



LIST OF REFERENCES

- 16 ... exhaust manifold
- 17 ... exhaust pipe
- 18 ... SO<sub>x</sub> absorbent
- 19 ... NO<sub>x</sub> absorbent
- 24 ... bypass passage
- 27 ... switch valve